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The Cargo Carrier of late Antiquity, Studies in Ancient Ship Carpentry

by

CHRISTOFFER H. ERICSSON

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FOREWORD

Professor Christoffer Ericssons book on the merchant ships of classical antiquity does something to redress an imbalance, to which he rigthly draws attention, in the history of seafaring. Warships have claimed the greater share of the historical limeligth because from time to time they play a striking role at turning points in the fate of maritime nations, and, more trivially, because their oar-systems have presented, and still to a great extent present, such an irritating puzzle. Merchant seamen, however, from the earliest time have pursued their lawful, and unlowful, vocation in the Mediterranean and adjoining waters, and steadily and quietly have increased wealth and provided the nourishment for the urban populations of the area. The comparative neglect of their ships is largely the result of the silence of the ancient texts (with one or two notable exceptions) in their regard, and until recently the absence of archaeological information about them.

Now the invention of the diving suit and more recently of the aqualung has enabled archaeologists to explore first the bottom of Lake Nemi and then since the Second World War the sea-bed of the Mediterranean, and a good deal of information has resulted. Professor Ericsson has carefully and logically assembled in his various chapters this body of knowledge from very varied sources. He uses the Nemi-ships quite legitimately in spite of their untypical shape and purpose, to illustrate the building methods and attest some of the gear of the Roman merchant ships of the second half of the first century AD. He is also able to use the north African mosaics for a study of the sails and rigging.

Professor Ericsson is a practical seaman as well as a scholar, and his book, which he has done the English-speaking world the honour of translating in our language, is likely to command a wide interest, and readership, among his colleagues, both practical and scholarly, and some, like him who are both.

J. S. Morrison, Professor

Granhams, Great Shelford,
Cambridge

AUTHOR'S PREFACE

The present study of the cargoship of late Antiquity was drafted and assembled in 1968-71, but based on observations and material collected during extensive travelling in the Mediterranean area in the 1950:s and 1960:s. Of special importance were visual impressions of the Nemi-hulls – the "Galleys of Caligula" – recovered and excavated in the early 1930:s, and during these years the subject of immense interest to the public, to newspapers and to a variety of sholars. The real importance of these complicated remants of Roman ship-carpentry was not fully understood at that time as most writers stressed the assumed functions of the enourmous hulls as floating palatial gardens, as well as the apparent high quality of works of art revovered.

In the early seventies the author was fully engaged in the organization and development of working teams and equipment for underwater arcaeological work, as well as in publishing reports and studies concerning maritime research. In addition to these activities, the author established a reference library for the new governement institution for nautical research, in consequence of which a great many journals, publications, off-prints etc. reached the author, not least from the Mediterr anean area, all of which were valuable sources of information. These duties precluded the "polishing" of the present monograph into its final shape in a European language; consequently it was simply filed during the 1970:s during which time the undersigned concentrated on aspects of Roman topography and architecture. Nevertheless the author was well aware of relevant archaeological activities and of new studies from the area in question endangering the validity of the manuscripts conclusions, all of which made prompt publication vital.

In 1978 an agreement was reached with the National Maritime Museum in Greenwich. The study was translated into English in 1979 and delivered early in 1980. The Museum instructed Professor John Morrison of Cambridge (the co-author of the important "Greek Oared Ships") to amend the language, to verify references, excerpts and classical citations. In March 1981 the manuscript was accepted for publication by the Trustees of the Museum, but production was delayed for various reasons until the autumn of 1983, when the project was abandoned, owing to reductions in running expenses ordered by a new director appointed in August 1983. In March 1984 the author received the present text, edited and arranged "camera-ready" for immediate production. Six years had been lost by this interlude, but a total of twelve years had passed since the original date of the study.

During the 1970:s many important developments took place in maritime archaeology and research especially within the Mediterranean area. Thus we have reason to ask whether this study is still valid? The situation requires a survey of literature published from 1972 until the present.

In 1971 Lionel Casson published "Ships and Seamanship in the ancient World", a book both of merits and of general interest. Here Casson, in a brilliant way, sums up his numerous studies on nautical matters in the classical journals and demonstrates his enormous maritime knowledge.

In 1974 Thames & Hudson published "A History of Seafaring based on underwater archaeology", a piece of teamwork by first-rate nautical scholars edited by George Bass. Here Peter Thorockmorton presents a note worthy review of ships and shipping during the Empire, using almost the whole of contemporary representations including reliefs, mosaics, coins etc. The principla wrecksites within the Mediterranean are commented on, but novelties in carpentry, joints, fastenings etc. are not listed.

"Die Römische Flotte: Classis Romana" by H.D.L. Viereck is a large-scale but inaccurate book not founded on sources considered reliable and acceptable to classical students; illustrations include free-hand drawing and sketches. Interest given to the cargo-carrier is limited to a mere 30 pages. The author does not discuss either the structure or the carpentry. Appended to the book are plans, deckviews etc. of the Nemi-hulls borrowed from Ucellis study.

Of the greatest importance is the Italian "Archeologia Subacquea: storia, technice, scoperte e relitti (1981) by Pero Alfredo Gianfrotta (Italian) and Patrice Pomey (French). The joint authors are principally concerned with the Mediterranean and Classical Antiquity, and the pictures are of the highest order covering every recognized archaeological survey of wrecks or cargoes submerged. The chapter entitled "architettura navale antica e i relitti" is a masterly piece of work dealing with hull-sturctures; the illustrations show close contacts between the joint authors and leading field-archaeologists active in the Eastern and Western Mediterranean. Borrowed sketches and underwater photographs cover ship-carpentry over a period of a thousand years. In the chapter entitled "I principali relitti" the foremost wrecks of Antiquity within the area (a total of 20) are described. This extraordinary book is unfortunately still available only in Italian.

From the start of the "Ina Newsletter", published by the Institute of Nautical Archaeology (USA), Mediterranean underwater activities were reported in great detail; most important are the wrecks at Yassi-Ada (Aegean Turkey) or Kyrenia (Cyprus) which have been visualized in templates and models. – Much interest in underwater-activities is shown by the ubiquitous "National Geographic Magazine" in popular articles written for the delight of its readers.

Minor hulls, barges, rowing-boats etc. generally not observed were brougth to ligth during airport constructions and earth-levelling at the Fiumicino Aeroporto Lionardo da Vinci, which are identical to the Claudian outer harbour = the roadsted of the Trajanic port. Hulls recovered are not drafted nor recovered but stored in a shed close to the passenger terminal.

During excavations along the ancient waterfront of Herculaneum, terminating as a hollow vaulted terrace housing boatsheds, a rowing-boat fully intact but charred was excavated in an upside-down position – as to an article in the mentioned "National Geographic Magazine".

Nautical equipment, previously largely ignored when recoverd amidst works of art, today receives better attention from a specialized staff. The lead fittings of the composite anchor are observed in great numbers, indicating spots of danger with frequent strandings. Gerhard Kapitän, resident in Syracusa, presented an attempt at a typology in an article in the series Marine Archeology of the "Colston Papers" in 1971. Sligthly earlier, Perone Mercanti dealt with ancient anchors in "Ancorae antiquae per una cronologia preliminare della ancora del Mediterraneo". Piero A. Gianfrotta contributed to the Memoirs of the American Academy in Rome (MAAR), XXXVI, (1980) in an article "Ancorae Romane, Nuovi materiali per lo studio dei traffici marittimi.

Georges Rouanet presents technically advanced pumps in late wrecks from the Empire in "Etude de quatre pompes a eau romaines, provenant de l'epave Dramont D.", Cahiers d'archeologie subaquatique, III (1974). In "History of Technology", Vol. 5 (1980) Thorkild Schiöler discusses Roman piston pumps in a broader sense. Gianfrotta and Pomey in their previously mentioned joint work specify the fittings of the rigging, blocks, rings and fairleads etc. which apparently were sewn to sails. They, together with other writers, stress the importance of lead as a material for almost every purpose which was consumed in vast quantities for underwater sheating withs its antifouling properties.

The in-coming graintrade toward italic ports, activating the organized long-distance carriers of the Empire, is taken up by Geoffrey E. Rickman in "Roman Granaries and Storebuildings (1971), as well as in "The corn-supply of Ancient Rome", Clarendon Press (1980), and in a short article in the MAAR XXXVL (1980): "The graintrade and the Roman Empire". This volume is entirely dedicated to seaborne trade of the Empire. The Swede E. Tengström concentrated on the corn-supply of the Capital in "Bread for the people: studies in the corn-supply of Rome during the late Empire" (1974).

The topography of the mercantile installations in the Ostia and Portus area is displayed in the small Museo della Via Ostiense, arranged in the twin walltowers of the Porta San Paolo (Porta Ostiense) and described by a guidebook in the Blue Series, published by the Italian Ministry of Education, by Maria F. Squarciapino. The first-rate port of Puteoli is the subject of an article by J.D. Arms: "Puteoli in the second century of the Roman Empire a social and economic study, in the Joumal of Roman Studies, 64, (1974).

Also the effects of weather and prevailing winds are studied with reference to the trafficarea of the Ancient World. See: A. Trevor Hodge, "Massalia meteorology and navigation" in the journal The Ancient World, Vol. VII (1983). New dimensions are continually being added to the study of the Classical World.

* * *

The present review of ancient research is far from complete and is utterly selective. It should be noted that the once important philological interpretation of texts often resulting in illogical and impractical considerations, now seem to have been more or less abandoned. We have reason to ask, should the books and articles here listed be seen to affect the validity of this study? This, it should be noted, is a survey of ship-carpentry, structure and practical ship-handling. Thus, physical = archeological objects or remain or representations = works of art are required to amend or cancel the conclusions of the author of this study. Greek and Roman literature remain static, new texts being added only by extraordinary lucky finds of papyri. Newly discovered texts relevant to sea-faring or shipbuilding are not to hand. Since the discovery of the mural painting in the Etruscan Tomba della Nave (Moretti 1961), no works of art affecting the concems of this study have been published or reported. Only underwater archeological material from recently excavated sites may seriously affect the study. W thus have reason to question whether single objects, structural fragments or whole timer-assemblies located and studied from the early 1970:s will seriously affect the lay-out of the cargocarrier of the early Empire presented in this study.

Wrecks located during the past 10-12 years (mainly by US/Turkish collaboration) within the Eastern basin, cover the classical and hellenistic, as well as the Byzantine centuries only, but actually not those of the Empire. The interesting fragment of a stern, recovered at Pantano Longarini (E. Sicily) and excavated by Throckmorton and Kapitän (1968) dating from very late Imperial epoch, is unfortunately not complemented by hullfragments of a similar nature. Fortunately a large cargoship with a full load of amphorae dating from late Republic was excavated at Madrague de Giens (S. France) from 1972 onwards using the latest methodology and techniques. The hull, with a capacity of approximately 400 metric tons, is heavily dimensioned but corresponds structurally to the standard principles of carpentry of Antiquity. See Tchernia, Pomey and Hesnard in GALLIA, Suppl. XXXIV (1978).

Material recovered from numerous sites confirms a nautical standardization irrespective of location within the Mediterranean area, East or West. Such a common language of nautical architecture is observable already in the 1:st century A.D. Was it possible that also seamanship, shiphandling and navigation proper were internationalized in a similar way? The standard of design and structure may have been that of the Imperial Navy, in as much as the Nemi-hulls, built to court-specifications, are understood to have been built by shipwrigths and ratings from the naval yards. These large hulls were unfortunately destroyed by the perils of war, but they were fortunately documented in a masterly way and the evidence they provide has not been significantly modfied by the remnants of a more recent date: a situation the author of the present study has sought to emphasize in the above review of maritime research and literature.

Helsinki in August 1984

Christoffer H. Ericsson

CHAPTER I

(i) The Navis Longa and the Navis Oneraria: an introduction

Within the Mediterranean we find throughout early as well as late antiquity two basically different types of ships: the long ship *(naus makra, navis longa)* and the round ship *(naus strongulē, navis oneraris).* The oar-propelled long ship is a military tool designed for the maximum mobility and speed in battle; consequently we find light construction and a high length/breadth ratio[1]. The round ship is built to carry cargoes at a minimum of expense with no requirement of speed and hence of anything more than wind propulsion. The oar-propelled long ship relies on the wind only for getting from place to place, not for combat, while the round ship with low length/breadth ratio must in a calm rely on towing by oared boats or ships. Occasionally the long ship was used for transportation of troops, military equipment or horses[2], but seldom for the carriage of merchandise. We are in a position to trace the successive development from primitive hulls towards clearly defined warships within the Egyptian civilisation[3], and we may note similar achievements among the Bronze-Age cultures of the Aegean, yielding a rich archaeological material, exhibit a variety of sea-going craft, observable in ceramic objects or in gems. The light oar-propelled warship is easily distinguised from the cargo-carrier, which is often depicted with a sailing rig. Within the sphere of Greek culture proper we are able to trace the development of the oar-propelled vessel from the proto-geometric period onwards as represented in painted pottery[5]. Vases of the geometric style, in a vivid yet technically unreliable manner, record long ships of considerable dimensions, whereas nothing of interest is to be found in vases of the Corinthian style. The richest source is represented by the older, black-figure, style of Attic vase-painting, which shows a strong interest in maritime matters, while the later, red-figure, style depicts only rarely in illustrations, of mythological stories. Other groups of ship-representations are scarce within Greece, as well as within the spheres of the eastern continental powers. The lack of nautical representations from the Phoenician centres has been explained as a deliberate security measure to preserve important mercantile secrets.

From the fourth century BC onwards the documentation of contemporary maritime development ceases with the end of the production of painted pottery, which was, unfortunately not replaced by a new pictorial art. As far as the Hellenistic period is concerned this brilliant civilisation may be brought to life from its own literature, but economics and industrial and technical matters remain obscure. Sea-borne trade and ship-building are illustrated only from haphazard remarks and anecdotes[7]. The merchant vessel and the principles of its construction are totally overshadowed by the warships of the navies of the Hellenistic rulers[8]. Yet within the eastern basin of the Mediterranean documentation of material culture is fairly good by comparison with conditions in the Italian peninsular, within the western Greek colonies and the Phoenician-Carthaginian trade-establishments, about which our knowledge is almost nil. We possess only a strictly limited number of Etruscan ship-representations, equally valid for the Italian as for the Etruscan area[9].

The archaeological material from late antiquity builds up the accepted picture of an international, firmly regulated, shipping industry geared to the seaborne trade of the entire Mediterranean world. Thanks to the Roman habit of documenting important events, organisations and public decisions in epigraphy, in memorial tablets and in mosaics, we are well-informed about shipping in general, as well as about the basic types of cargo-carriers from the first to the third centuries AD. Of special importance are the reliefs on sarcophagi in which maritime subjects became popular. Equally important are frescoes in burial chambers and simple reliefs on stelēs excavated on the 'Isola sacra' flanking the mouth of the river Tiber. Compared to such material, documentation from the centuries following the division of the empire until the end of organised Mediterranean trade is inferior. This period, which does not formally belong to late antiquity, is rarely the concern of the present study.

The Purpose of the Study

The subject of this study is the sail-propelled carrier from the Greek archaic period until the late Empire, as it slowly developed within the sphere of Graeco-Roman civilisation. Included are the sea-going ships of neighbouring civilisations, e.g. those of the Etruscans but not those of the continental Semitic countries. We shall as far as possible examine ship-building within the Hellenistic kingdoms as well as the extent of seaborne trade and shipping activity in the eastern Mediterranean during the three relevant centuries. Special attention is paid to the sail-propelled cargo-carrier, the *corbita* of the Empire, on account of the ample documentation of this type, as well as of its minor variation developed for coastal or river traffic. This study concerns hull-design, rigging and sail, equipment, propulsion and handling, grouped as follows:

- hull-design and principles of construction
- the steering-oar and relevant problems
- equipment and power-machined on board ship
- rigging, sails and sailing capacity
- handling of the cargo-carrier and docking and hauling-up of the hulls.

(ii) A Review of Earlier Research

Antiquarian interest in ancient shipping in earlier times

Interest in maritime matters of ancient times, especially in the types of ships and craft, was awakened during the Renaissance as a result of attention directed to the classical world and in particular to objects of art which were being excavated, principally fragments of sculpture[11]. Carried out by dilettanti such researches brought no positive results[12], but continued until the beginning of the 19th century when classical scholars on the one hand, and naval officers and master mariners, mainly French and German, on the other, started a new era of more serious research. This stage may be typified as the interpretation of the available literary sources and analysis of works of art, vase-painting and sculpture. Actual remains of ships did not exist nor were expected. Like the scholars of the Renaissance, these people concentrated on the oar-propelled warship, and the problem defined as the riddle of the Greek trireme. Interest continued during the course of the 19th century, and a considerable literature was accumulated[13]. From the beginning of the 20th century new trends were clearly observable among scholars, mainly English-speaking. While the philological approach predominated, technical details of oar-propelled ships and the distribution of rowers attracted interest.

Research in the early 20th century

New material now began to be introduced, in part as a consequence of dry excavations, in part from submarine finds of works of art, of pieces of hull, ceramics, dunnage for stowage of cargo, and hull-remnants of less importance. Such material, in most cases, was brought to the surface by Greek or Turkish sponge-divers within the eastern Mediterranean. The new material did not change the basic character of the matters studied, yet it indicated the possibilities, offered by underwater archaeology, of supplying men of learning with fresh evidence. In the early 20th century these promises were in fact fulfilled[15]. Material of great importance was made available when the so-called 'galleys of Caligula' were recovered and excavated from Lake Nemi. These operations started in 1928 with the lowering of the level of the lake, in the mud of which the huge hulls were found astonishingly well-preserved. The excavations were excellently directed and published, but the results were only made available in the course of the second World War[16]. Thus numerous features of imperial hull-technique and ship's carpentry remained unknown. These important principles which were in fact common to naval architecture throughout late antiquity were taken into account by only a limited group of mainly Italian technicians and professional naval architects.

Development after the second World War

The second World War occasioned a great development of self-contained light diving-equipment. Afterwards civilian industry was able to produce a series of efficient kits of this kind at reasonable prices. Thus in the nineteen-fifties a spate of underwater activity began directed towards ships and ship-remains. The main theatre for such early wreck-investigation was the western Mediterranean. The survey and excavation of the wreck of a large-scale cargo-carrier at the island of Grand Congloue to the south of Marseilles turned out a model operation in many respects. Not only the cargo but also minor fragments of the hull were recovered, analysed and duly published[17].

From the late nineteen-fifties onwards underwater archaeology became step by step a serious branch of humanistic study, using tools and equipment of accuracy and efficiency. Because of the high level of expense, sponsors had to be found, and universities of the U.S.A. accordingly appeared frequently as sponsors or organisers of underwater research in the Mediterranean. The objects of study were now without exception cargo-vessels. Wooden hulls are soon destroyed in seawater if they are not covered by sand or by cargo of inorganic material. The remnants found under layers of *amphorae,* the standard containers of antiquity, usually consist of fragments of floors, of inner and outer planking, but not of deck-beams or of bow or stern timbers. On account of the destructive activity of the teredos, with one possible exception, remains of warships have not been found. In addition to the lack of a protective cargo the overall light construction of the oar-propelled warship may have resulted in disintegration of the hull when grounding. Further we may assume that the long ships of early antiquity were extremely light, sparsely equipped and unballasted, so that when filled with water they would still float.

Underwater archaeology has supplied us with a rich fund of works of art, architectural fragments and semi-fabricated elements, various types of *amphorae* and mass-produced ceramics for export. Yet the amount of items of value for understanding ancient naval architecture has really been very modest. In addition to the important French wrecks mentioned, hull-fragments of a large late-Roman carrier were found on the south coast of Sicily covered by sand. The ship had been caught by the sand when stranded so that a lagoon of brackish water built up around the once almost intact hull. Badly mutilated by local farmers it was excavated and measured but is not yet published in detail[18].

Minor fragments of the bottom timbers of carriers' hulls have been located at Cape Gelidonya[19] and in the Gulf of Tarranto[20]. Details of the latter are not yet available. From the cases mentioned and from the constant increase in underwater archaeological activity it is apparent that more numerous and especially more valuable submarine remains will be located. Thus older methods of research, mainly interpretations of ancient texts and works of art, in the near future may be replaced by surveys of actual remains as evidence for ancient methods of naval architecture. Thus it can be said that in the nineteen-fifties research into ancient shipping and shipbuilding entered a basically new phase.

Irrespective of such prospects the oar-propelled Greek warship has recently been the object of serious study at a high level[21]. The authors analysed the complete known material of fragments from art and applied arts as well as of literary excerpts, relying on a strictly philological method. Further we have to observe the studies of the oar-propelled vessel, irrespective of epoch and geographical sites, by a private Belgian scholar[22]; his study is not affected by material supplied by marine archaeology. The sail-propelled cargo-carrier has not been the object of serious study.

(iii) A Review of the Literature

Basic sources: Greek and Roman authors

The works of Greek and Roman authors constitute the most ancient basic material for research into nautical matters and naval architecture in antiquity. The material in question was already to a considerable extent known and utilised by the scholars of the early Renaissance. From the second half of the 15th century this fund was increased by the activities of collectors searching for manuscripts in monastic institutions as well as by the importation of Greek texts from the Byzantine area. Archaeological material was still insignificant and increased only slowly. To the scholars of the 15th and 16th centuries, keeping to their desks, this literary material was difficult to understand and alien in every respect, since they lacked, as illustrations, the reliefs, mural- and vase-paintings, mosaics, coins, models, and finally actual fragments of, or complete preserved, hulls from antiquity. Theories derived from ancient texts were often logically impossible or absurd, and stressed that the humanist of those times was well trained in classical languages but understood nothing of things maritime. Nor was he aware of contemporary Italian oared vessels which in fact presented valuable material for comparative study. The importance of the Italian navies and their ships as objects of study in this connection only dawned on scholars in the early 17th century.

In spite of the great number of ancient authors mentioning shipping and ships in a wide variety of texts we find little of real importance in as much as maritime matters are mentioned by chance only and as of secondary importance. Very few authors narrate first-hand experience but are referring to hearsay. We never find facts presented by professionals comparable to Thucydides' or Caesar's reports of military events. Personal experience of service on board ship in a military capacity is not found in literature. We are unable to find descriptions of the actual use of oars or of the handling of sails, nor do we find facts about the commercial operation of merchant shipping. We do however possess facts about the administration of ports and the proceedings of corporations or guilds concerned with the management of a harbour. As a rule comments on maritime matters are to be found in governmental or public contexts, while purely mercantile and private relations on the other hand are almost impossible to trace in contemporary texts. In the space of a millennium, from the birth of Greek epic poetry in the early eighth century until the writers of late imperial times the building principles of ships, their handling and the basic element of navigation remained a closed book to men of education and letters.

It was only by chance that a Greek dramatic author caught up haphazard fragments of a conversation between ratings manning the oars of the city's galleys. Such rough talk, given a political point of contemporary significance, was the stuff to appeal to a theatrical audience. To all categories of writers seaborne trade and its instrument, the sail-propelled cargo-carrier, were an unknown quantity.

In spite of such limitations the sum of haphazard facts, of terminology preserved or of odd, apparently unimportant, comments, was of a very great value as soon as it passed into the hands of scholars not devoid of knowledge of nautical matters. Such a conjunction was made as late as the closing decades of the 19th century, to be continued today in the form of renewed criticism and analysis. Earlier interpretations are thus revised and logically impossible or obscure conclusions are suitably corrected.

Epigraphy constitutes a clearly defined group of evidence, usually from official archives. Most important are the 'tabulae curatorum navalium' published in the *Corpus Inscriptionum Atticarum.* These Greek texts relate to the organisation and financial administration of the Athenian navy. This large epigraphical source has produced a number of important facts concerning the dimensions, equipment, rigging details and maintenance of the Greek *trieres,* but nothing at all, naturally, about mercantile affairs.

Greek Authors in Early Antiquity

Homeric poetry may be said to face the sea, which was the scene of a great part of the action described, but in spite of this we never find a detailed description of the light, oar-propelled, undecked ship which carried the heroes and their companions. Yet this all-important tool appears in the texts with a great variety of adjectives attached. The Iliad depicts, in the 'Catalogue of Ships', the means by which armies were transported in the late Mycenaean era. This great concentration of sea-power we find assembled in the camp of the Achaeans on the Trojan shore. The Odyssey, on the other hand, provides a noteworthy amount of information on ships, their propulsion and their low standard of seaworthiness. The maritime scholar directs his attention to the description by Homer of the community of the Phaeacians at Scheria (sometimes identified as the island of Corcyra i.e. Corfu). The Phaeacian way of life is described as exclusively nautical, wholly turned to seaborne trade, where the general interest focuses on the undecked, oar-propelled, ship, using sails as auxiliary power. In this description we find a lot of information about simple standing and running rigging, on the stepping of masts and hoisting of sails, with numerous hints on running upkeep and storage, on launching and beaching etc.

The poetry of Hesiod stresses the grave dangers as well as the financial risks connected with maritime trade. Yet his text underlines the poet's position within the agrarian community in the 8th or 7th century BC by expressing a total ignorance of nautical matters. The epigrammatists like Simonides, Callimachus, or Archias in the early Eipine, all stress the dangers associated with navigation, expressing them in the condensed form of a funerary epigram. To an established community the total loss of a ship with all hands, causing men to find their graves in the sea's abyss, was a shocking catastrophe.

The historians of early antiquity, to whom should be added the geographical writers, supply us with numerous odd pieces of information on ships and maritime trade connections, but their real interest lies in naval operations and its instrument, the oar-propelled warship. In the work of Herodotus we find a lot of information on the principles of navigation, on rigging details and technical elements in the oar-propelled hull. As to merchant shipping, he lists various cargoes and the weights of important commodities handled, together with the various systems of weights acknowledged. In his text we frequently find odd notes of an anecdotal nature, which may yet be of the greatest value. Thucydides restricts himself to the description of naval operations, and to the logistics of these operations, during the Peloponnesian war. In a number of places his text provides detailed information about the highly developed oar-propelled warships of classical Greece. The history of Polybius, which concerns the Greek and Carthaginian wars of Rome, mentions naval battles but avoids nautical details. Some information about the rigging of oar-propelled warships is to be found in his text. Diodorus of Sicily, who was active in the times of Caesar and Augustus, is the author of the impressive *Bibliotheca Historica,* in which we find only haphazard pieces of information about mercantile shipping, mostly relevant to Egyptian conditions, since these were of special interest to the Romans as the sphere of grain supply for Rome and Italy. Strabo also, writing in the Augustan age, makes no mention of maritime trade, though he supplies us with occasional pieces of interesting information, e.g. on the appearance of early, wrought-iron, anchors.

The Greek dramatic authors, as active members of their community and experiencing the compulsory military service of citizens, were thus in possession of a multitude of facts about the Athenian navy, its maintenance and personnel. From Aeschylus we learn facts about ground tackle, hawsers and decorative eyes in the bows of warships. Euripides, by a happy chance, relates the method of raising anchors to the catheads of the *trieres.* Aristophanes supplies us with exact measurements of the anchor cables for various categories of warship and with information about the carrying of cavalry-horses in warships during the contemporary Peloponnesian war. We also learn from him the unpleasant consequences of being seated in the fouled air of the lower rowing benches of a *trieres.* Yet seaborne trade, the mother of Athenian commerce and of her hegemony of Greece, is nowhere mentioned by dramatic writers.

The Athenian navy had a direct impact on the life of the man in the street, which the dramatists knew well, while merchant activities were background functions.

Turning to the Greek philosophers we may note that Theophrastus, the contemporary of Alexander and his successors, comments in his *Historia Plantarum* on the various woods and their usefulness for ship-building. The work is of real importance for the study of ancient ship-construction. Aristotle, a versatile man who touched on a great number of practical questions, mentions seafaring and the handling of sails. In the *Mechanica,* which is doubtfully of Aristotelian authorship but is usually attributed to the Peripatetic school, there is a number of theories on windpower and the proper handling of sails.

Greek Authors in Late Antiquity

Among the authors using the Greek language in Imperial times there is a very limited number which are interesting from a nautical point of view: Lucian, Athenaeus, and the Roman Appian, who was born in Alexandria and probably for this reason wrote in Greek. Lucian, born in the reign of Hadrian and active in Athens, had a manifold literary production, which included a story of an Alexandrian wheat-carrier in the Ostia- and Portus-trade which called at Piraeus in an emergency. The extraordinary dimensions of the visiting ship attracted curious Athenians to the port area. The description of this vessel, composed in the form of a dialogue, includes technical and nautical details which fit the known representations of this class of cargo ships and may be considered the most reliable account available of the mammoth carriers of the Roman wheat trade.

Appian, writing in the second century AD, is the author of a history of Rome, the *Romaika.* It is of no special merit, being based on dubious sources. The evidence he provides mainly concerns oar-propelled ships.

Athenaeus, who was active in the second century AD, is known for his *Deipnosophistai* ('Sophists at the Dinner Table') which is a composition made up of elements borrowed from authors of earlier antiquity. A number of these are either unknown or present evidence which is unverifiable. Among the latter is Callixenos who refer to the quite unknown Moschion as speaking of the mammoth ship 'Syracosia-Alexandris belonging to Hieron II of Syracuse. The story is generally considered to be of dubious authenticity. Callixenus also describes Ptolemy Philopator's 'Forty'.

Roman Authors from the Civil Wars to the Late Empire

Roman authors of the Republic mostly lacked knowledge of nautical matters, except in so far as this might be interwoven into epic poetry, into narratives of naval warfare or of current political events. They had, maybe, private experience of travelling at sea to a province or a theatre of war. Cicero as well as the poets of the Golden Age like Catullus, Vergil (who handled antiquated mythological material) or Ovid, mentioned various types of ships and boats yet omitted all facts of real importance to the understanding of structual details. The same is true of the historian Livy. Pliny the Elder, thanks to his profession and his engagement in practical and military affairs as well as in technical matters, supplies us with numerous facts and valuable notes on naval affairs, service conditions, and oar-propelled warships on the decoration of warships, on materials used in ship-building etc. Pliny further speaks of the trade with India under the Ptolemies by the *periplus* route to Barygaza and Calliena, revived as a Roman enterprise in the Julio-Claudian era. Seneca, a contemporary of Pliny and thanks to his position always well-informed on governmental questions, supplies us with facts on the grain-trade through Puteoli and Ostia organised in the reigns of Augustus and Tiberius. Suetonius seldom mentions matters of maritime nature, but he is well-informed on the difficult sea-transport of obelisks from Egypt ordered by Caligula. Valerius Flaccus, active under the elder Flavians, touched upon nautical matters in the *Argonautica* but relies on borrowed facts of secondary importance, e.g., on the decoration of hulls. Ammianus, writing in the reign of Julian the Apostate, is the author of *Res Gestae*, but borrows his facts from earlier authors and thus lacks importance. His account of the transport of obelisks refers to earlier centuries.

Christian Authors

The narrative of Paul the Apostle, describing his voyage from the Syrian coast to Italian Puteoli, including the total loss of his ship, possibly at Malta, must be regarded as the finest and most complete report in ancient times of a rough passage in the open sea in spite of the scanty text and possible corruption. In spite of being a land-lubber, lacking knowledge of the principles of handling a sailing vessel, Paul supplies the reader with a set of very important self-explaining facts fitting exactly the representations from the early imperial period.

Synesios of Cyrene, bishop of Ptolemais in 409, wrote a narrative of a sea-voyage in a ship apparently carrying lateen sails, a new rig in the Mediterranean.

Paulinus of Nola living in the fifth century supplies us with odd notes on shipping of no special importance.

Procopius, the military author and historian of Justinian's campaigns belongs to the early medieval period, and the same is true of Synesios and Paulinus also.

Modern Literature: classical scholarship, history, archaeology

The scholarly literature published before the 19th century should be regarded as amateurish studies, although within the sphere of classical scholarship. Nautical knowledge was not available, nor was such knowledge expected of scholars. These studies never concerned mercantile seafaring or seaborne trade by reason of the general lack of interest in trade, commerce and shipping typical of Greek and Roman writers, an attitude which appears to have had its roots in the warlike aristocratic spirit of Homeric poetry which has been already stressed.

About 1840 this literature took a more serious turn with publications such as A. Boeckh's *Urkunden über das Seewesen des Attischen Staates*[23] and the works of A. Jal[24] from 1840-61, marking the beginning of the study of the oar-propelled ship and the discussion which followed, while the year 1874 witnessed the publication of W.S. Lindsay's *History of Merchant Shipping and Ancient Commerce* in four volumes.

A number of authors joined in the debates about the above questions: Paul Serre[25], A.G.C. Cartault[26], A. Breusing[27] E. Assmann[28], J.G. Droysen[29], L. Fincati[30], and B. Graser[31]. Yet nothing of importance was brought forward. The cargo-carrier of antiquity was virtually unmentioned by any of them. The German language in fact dominated the scholarly activities centres round the ships, the oar-propelled warships of the Greeks and Romans. Typical of such literature was *Das Seewesen der Griechen und Römer* by E. Lübeck published in 1890-1. Cecil Torr published his *Ancient Ships*[32] in 1894 treating the oared ship in early antiquity but also providing a manual on hull-construction, equipment and handling, of considerable importance. Torr's references to Greek and Roman literature and excerpts therefrom are still valued by maritime scholars. Articles by Torr and W,W, Tarn[33], as participants in a long debate, were added to a recent edition of Torr's book. Yet nothing of importance regarding the cargo-carrier is found in this study with the exception of some brief comments. The eighteen-nineties witnessed fierce scholarly discussion of seafaring questions in antiquity, but nothing so far emerged of lasting value. It should be noted that Italian and.Greek scholars did not participate.

Nothing of interest occurred in this field in the early 20th century. In 1923 A. Köster's *Das Antike Seewesen* was published, in which the author attempted to tackle every nautical aspect of antiquity. He was however unable to deploy the methods of classical scholarship, and was inclined to subjective conclusions. His illustrations were arranged haphazardly and are often of dubious value, being sketches of photographic originals.

At the end of the first World War there was a change in the situation when the Italian government increased archaeological activities within the country. At Ostia the imperial town was dug out of the sand, and activity at Lake Nemi resulted in the excavation of the legendary 'galleys of Caligula', in reality two shallow-draught barges of large dimensions. Various finds (epigraphical material, mosaics etc.) unearthed at Ostia were related to commerce and shipping during the imperial period, the importance of which became apparent. Scholars interested in Ostia and the nearby Portus, the artificial harbour constructed to the north of the difficult mouth of the Tiber, directed their attention to architecture and town-planning, but ship-handling, wholesale trading and the storing of grain attracted its share. Names of importance are G. Calza, G. Becatti, J. Gismondi, G. De Angelis d.Ossat and Russell Meiggs[35]. G. Lugli and G. Filibeck's work on the Imperial ports, 'uterque portus', *Il Porto di Roma Imperiale e l' agro portuense* (1935)[36] is still relevant.

A number of specialists shared in publication of the excavated Nemi-hulls which yielded rich finds of art, carpentry, metal fittings and details of plumbing. G. Uccelli presented his studies of the two hulls from the point of view of the naval architect in *Le Nave di Nemi* published in 1950. In the nineteen-thirties the picture of the way in which the large-scale, government-regulated, victualling of Italy was carried out during three centuries was considerably clarified. Now facts were collected relating to the carriers of cargoes known from literature, mosaics or inscriptions. For the technically minded the observations made of the Nemi-hulls – or more correctly pontoons – were of immense importance.

A.W. Gomme's study *Traders and Manufacturers in Greece* appeared in 1937. Relevant to the grain-trade and to local cargo-handling are L. Casson's *The Grain Trade of the Hellenistic World* and *Harbour and River Boats of Ancient Rome*, both published after the second World War[39].

The period from the late nineteen-forties onwards is marked by a fresh interest in seafaring and shipbuilding in antiquity, which is now focussed on the physical remains of the actual ships, not on representations of them. The scuba-diver, independent of a manned working-platform and of permanent assistants, makes his entry in the early nineteen-fifties. His appearance marks the beginning of a new kind of archaeological activity, under the surface of the sea, to be ultimately but not unanimously accepted as a scholarly branch of the antiquarian sciences.

Work based on classical scholarship and orthodox archaeology had been published in the periodicals and papers of learned societies and universities mostly in the United States. Already in the nineteen-thirties the periodical called *The Mariner's Mirror (U.K.)*[39] was regarded as pre-eminent in the field of historical maritime research. Numerous important studies were published by learned associations in Europe and the United States: J.S. Morrison's study of the oar-propelled warship[40], W.W. Tarn's study of Hellenistic naval tactics and warfare[41], and Lionel' Casson's numerous articles on Hellenistic and Imperial shipping, technical questions and organisations at the main shipping terminals[42]. We have to stress the importance of M. Rostovtzeff's *The Social and Economic History of the Hellenistic World* in three volumes, in spite of the fact that the author regrets the scarcity of facts relevant to the maritime trade of the era. The same is true of his *Social and Economic History of the Roman Empire* and of T. Frank's *An Economic Survey of Ancient Rome.*

Among popular books on ancient seafaring where older and more recent views and conclusions are mixed, we should mention L. Casson's fine *The Ancient Mariners* (1960)[43] which contains excellent photographic reproductions and an exhaustive bibliography, as well as Zwi Herman's *Peoples, Seas and Ships* (1964), concentrating on seafaring among Semitic peoples, which should be regarded as a popular book lacking scholarly ambitions.

Already in the mid-nineteen-fifties underwater archaeology had showed results, published in the spirit of popular science in books and periodicals. In *Promenades d'archéologie sousmarine*[44], published in 1952, P. Diolé presented the most important underwater sites of archaeological importance in the western Mediterranean. N. Lamboglia and F. Benoit reported on sites along the Franco-Italian Riviera in *Scavi sottomarini in Liguria e in Provenza* (1953)[45]. The popular but important review *Archeology* (U.S.A.) opened its pages to underwater archaeology by publishing articles by G. Karo, L. Casson, G. Kapitän etc. The most complete report on a single wreck-site within the Mediterranean is F. Benoit's *L'epave du Grand Congloue a Marseille* (1961)[46] covering the archaeological investigation carried out on the wreck of a merchantman belonging to the Hellenistic period and loaded with wine for a Ligurian port. From the point of view of method Benoit's study is a model; the sections dealing with hull-construction and carpentry are also of great merit. In *Under the Mediterranean* (1963)[47] Honor Frost gives reports of numerous underwater sites, mainly port facilities, in the eastern and western basins of the Mediterranean, providing maps and sketches. The author later concentrated on a limited number of underwater harbour installations of special interest, publishing them in periodicals.

The above mentioned studies dealt with the cargo-carrier only, since the remains of oared-ships have never, with one exception, been located. The exception is the remains of light, owned hulls located within the waters of Phoenician Motya[48] on the western coast of Sicily.

To sum up, the achievements of about twenty-five years of fieldwork are of greater value (as regards cargo-carriers) than the entire previous period of study based on classical scholarship. In the material now available late antiquity predominates, while remains from archaic and classical Greek periods (with one to two exceptions) have not turned up. A summary of detailed results, with regard especially to the important periods between the first and second World War and after the second World War, would be a voluminous list not suitable to the present brief study.

NOTES TO CHAPTER I

1. J.S. Morrison and R.T. Williams *Greek Oared Ships 900-322 BC* is based on a vast material of literary and archaeological character relevant to the oar-propelled warship.
2. The transport of cavalry horses by sea is mentioned by Thucydides II 56 (Pericles' expedition to the Peloponnese). Old triremes were apparently converted for this purpose. Aristophanes *Knights* 595-606 also refers to cavalry transports. Ships so converted were called *hippagögoi* or *hippēgoi*
3. G. Halldin *Farkoster vid Medelhavets och Västeuropas Kuster* etc: *Egyptiska Farkoster* pp. 16-17.
   T. Säve-Söderberg *The Navy of the Eighteenth Egyptian Dynasty.*
4. Halldin op. cit. : Phoenician Ships pp. 31-38. Zwi Herman *Peoples, Seas and Ships:* illustr. of a tomb in Drah aboùl Neggah. *Histoire de la Marine* (Editié Par *L 'Illustration'* Paris 1934) pp. 29-32.
5. Morrison and Williams, op.cit. see the plates illustrating Greek vase-paintings relevant to ships.
6. Plastic representations listed by Morrison and Williams. Such objects belong to the *askos* and *rhyton* groups of painted ceramic, mainly Attic.
7. Axel W. Persson *Med Hacka och Med Spade; Sjöfart och Skeppsbyggnadskonst under Antiken*, pp. 90-95
8. Jurien de la Gravière *La Marine des Anciens* (out of date). Lionel Casson 'The Supergalleys of the Hellenistic Age' *M.M.* 1969 Vol. 55 2.
9. S. Paglieri 'Origine e diffusion delle navi estrusco-italiche' *Studi Etruschi* Vol. 28 Ser. 2 (1960).
10. The name was apparently derived from *corbis* = basket, in as much as a basket was hoisted in the rigging of the grain-carriers of the Egyptian run indicating the special privileges granted to this crack fleet at the harbour-terminals.
11. Codex Escurialensis Folio 66-68. Text: "Versuche die gattungen Römische kriegsschiffe zu veranschaulichen. Den hauptanhalt für solche Versuche bot ein damals in der Kirche S. Lorenzo fuori le Mura angebrachter Fries'. This relief was transferred to the Palazzo dei Conservatori on the Roman Capitol.
12. Lazar de Baif *De re navali* (1536). Pantero Pantera *L'Armata Navale* (1617).
13. Fincati *Le Triremi.* Cartault *La Trière Athenienne,* Weber *Die Lösung des Trierenrätsels,* Lübeck *Das Seewesen der Griechen und Römer.* Torr *Ancient Ships,* Tarn 'The Greek Warship' *Journal of Hellenic Studies.* For these books and articles see Bibliography.
14. A preface by J. Podlecki to the reprint of C. Torr *Ancient Ships* 196
15. Philipp Diolé *Promenade d'Archéologie sousmarine* Chs. 2, 3, 4, 6.
16. Guido Uccelli *Le Nave di Nemi* Instituto Nazionale d'Archaeologia e Storia dell'Arte: original publication 1940, new edition 1950.
17. Fernand Benoit'L'Épave du Grand Congloue à Marseille: Fouilles sousmarine' XIV^{e} Supplement to *Gallia.*
18. Peter Throckmorton and Gerhard Kapitän 'An ancient shipwreck at Pantano Longarini' *Archaeology* June 1968 Vol. 21 Nr. 3.
19. Carried out by the University Museum of Philadelphia under the direction of G. Bass.
20. According to a stencilled report from P. Throckmorton then resident at Athens.
21. Morrison and Williams *op. cit.*
22. Lucien Basch see specially 'Un modèle de Navire Romain au Musée de Sparte' *L'Antiquité Classique* 37 1.
23. A. Boeckh *Urkunden über das Seewesen des Attischen Staates*
24. A. Jal *Archéologie Navale* 1 and 2: ibid. La Flotte de Caesar. See also *Glossaire Nautique:* Répertoire polyglotte des termes de marine: anciens et modernes.
25. Paul Serre *Les marines de guerre de l'antiquité et du moyen âge. Études sur l'histoire militarie et maritime des Grecs et des Romains.*
26. Augustin Scorges Cartault *La Trière Athènienne: Étude d' archéologie navale.*
27. A. Breusing *Die Nautik der alten und die lösung der Trierenrätsels.*
28. Ernst Assman *Seewesen: Denkmäler des klassischen Altertums III* and *Die neueste Erklärung des Trieren, Penteren etc.*
29. Johann Gustav Droysen *Die griechische Kriegsschiffe, Heerwesen und Kriegführung der Griechen*
30. Fincati *op. cit.*
31. B. Gräser *De veterum re navali, Das trierenrelief der Akropolis; Untersuchungen über das Seewesen des Altertums.*
32. Cecil Torr *Ancient Ships* Cambridge 1894, reprinted and revised 1964. Of great importance for its references and excerpts from ancient authors, also for its comments. From a nautical point of view it is not so good. The illustrations of the new printing are not up to modern standards.
33. W.W. Tarn 'The Roman Navy', 'The Dedicated Ship of Antigonos Gonatas' *Hellenistic Military and Naval Developments,* 'The oarage of Greek warships'.
34. August Köster *Das antike Seewesen.* The sail-propelled cargo-carrier is mentioned in chapters 15 and 1. The author is fond of subjective conclusions and lacks scholarly method.

35. G. Calza *Ostia,* G. Calzi and G. Becatti *Ostia* (in the Blue Guide series) Itinerari dei Musei e monumenti d'Italia. Calza, Becatti, Gismondi, De Angelis Ossat, Bloch: Scavi di Ostia I; Tipografia Generale R. Meiggs *Roman Ostia.*
36. Archaeological activity within the area of Ostia begins with R. Lancianis *Richerche topografiche sulla Citta di Porto* (1868). Important are J. Carcopino *Il porto Claudio Ostiense secundo recenti testi* and K. Lehmann-Hartleben 'Die antiken Hafenanlagen des Mittelmeen in *Klio.*
37. After the second World War Lionel Casson presented important studies of seafaring and shipping in antiquity mainly concerned with Imperial Rome. As a classical scholar he published in classical periodicals papers on strictly nautical questions. In *The Ancient Mariners* (1960) he presented a popular book on seafaring in antiquity see note 43, the first since Köster's in 1923.
38. *Transactions of the American Philological Association, American Journal of Philology, The Classical Review.*
39. Publ. by the Society for Nautical Research, closely associated with the National Maritime Museum, Greenwich, London. This periodical maintains its position as the leading periodical for nautical research.
40. J.S. Morrison 'The Greek Trireme' *Mariner's Mirror* 27 (1941),' Notes on certain Greek nautical terms and on three passages in IG II 1632 *Classical Quarterly* 41 (1947).
41. W.W. Tarn *Cambridge Ancient History* Vol. 6 (1927) Ch.15, Vol.7 (1928). Chs. 3 and 22. *Hellenistic Military and Naval Developments* (1930).
42. Casson 'The Isis and her voyage' TAPA 31 (1950). 'New Light on ancient rigging and boatbuilding' *The American Neptune* 24 2 (1964). 'The sprit-rig in the ancient world' *MM* 46 4 (1960).
43. Casson *The Ancient Mariners* etc., including a bibliography with comments and indexes.
44. See note 15. The book provides useful information but makes no serious contribution. It appeals to the spirit of adventure.
45. N. Lamboglia presents part concerning the Italian section of the Ligurian coast in Italian, Benoit the part concerning the French section in French.
46. See note 17.
47. Honor Frost *Under the Mediterranean: Marine antiquities.* The work is based on the author's diaries on the investigation of wrecks, submarine ports, sites and combinations of objects including comments on and criticism of excavation methods. The author is academically trained and became one of the key people in British underwater archaeology in the nineteen-sixties. See Bibliography.

CHAPTER II

(i) The Navis Oneraria as represented in pictures and reliefs

The Greco-Roman oar-propelled ship was the subject of a great variety of representations which have been well presented by J.S. Morrison and R.T. Williams in their joint study covering the period up to the death of Alexander. A corresponding interest in the sailing cargo ship in antiquity cannot be found. This is particularly true in early antiquity, especially in the proto-geometric and geometric, but equally in the archaic and classical Greek, periods. While a great amount of descriptive popular art illustrated almost all aspects of Greek life, a comparable interest in seaborne trade and mercantile shipping was not apparant.

During the Hellenistic period almost nothing is recorded on the subject of naval or merchant shipping. In spite of a considerable volume of literature the sources for knowledge of nautical matters are insignificant. In the case of the great eastern kingdoms of the successors of Alexander scholars have to rely, to a considerable extent, on hypothesis only, when nautical matters are concerned[1]. The situation improved when Roman power extended to the Near East. Trade was organised to serve Rome as the imperial centre and eastern ship-owners were requested to develop ships of a specialised tonnage to handle grain for Italian ports.

Before the first Punic war Rome showed no interest whatsoever in the sea. She continued to neglect seaborne trade and ship-building, even when she was mistress of rich Sicily, the granary of the central Mediterranean. On the other hand the early emperors concentrated on the development of the river port of Ostia, as well as on the construction of the artificial facilities called 'the twin ports' *(uterque portus).* At this period we find numerous representations of sea-going ships as well as of barges and lighters for transshipment and various small craft for river work, representations which are of considerable importance. Such pictures, mosaics and reliefs, were commissioned by the various corporations active within the great terminals, or by governmental bodies eager to publicise their achievements in encouraging navigation[2].

In early antiquity coins frequently represent the swift oar-propelled warship, by preference the reinforced bow-section only, whereas in imperial times authorities preferred the sailing cargo-vessel in full figure, preferable one of the contemporary mammoths, as important units in the large-scale trading system under imperial control.

In the late imperial period we find cargo-ships on coins and mosaics but plastic representations are missing. From the period of the partition of the empire when the main stream of Mediterranean commodities was directed towards the eastern capital, no representations of cargo ships appear, except for some detail in the mosaics at Ravenna.

The material, which provides evidence of the merchant ship in antiquity, was with a few exceptions already collected by about 1900. Very few objects have been added after the publication of Cecil Torr's important *Ancient Ships* in 1894. The material is presented, arranged chronologically, in the following list for convenient reference in the present study. The starting point is the archaic Greek period (700–480 BC), thus excluding some eastern (Semitic) representation from the late Bronze Age[3], as well as some from the so-called Homeric period (900–700 BC), principally the terracotta models from Amanthus in Cyprus[4].

Representations of Greek Merchant Vessels

Period: Greek Archaic

Arch.1 *Krater* signed *Aristonothos epoiesen.* Probably of W. Greek origin? Excavated in Caere/Cervetri. Oar-propelled warship attacking a large-sized merchantship with raised bow and stern. A mast is indicated but yard and sail are missing.
Location: Palazzo dei Conservatori, Rome. Morrison and Williams Pl.9 a, b, c, Halldin Fig. 31.

Arch.2 Terracotta *pinax,* fragmentary, Greek 600–550 BC. The stern of a big cargo-ship showing the mast with shrouds and the yard with belayed sail lowered. Five *amphorae* indicate the nature of the cargo. Excavated in Penteskouphia. Furtwängler *Vasensammlung.* Halldin Fig. 71.

Arch.3 *Kylix,* Attic black-figured, no signature. 540–500 BC. (Plate I) Two slightly altered variations of the same theme. A small sailing merchantman under reduced canvas appears to be meeting a light warship with oars at two levels. The merchantman is light, floating much too high.

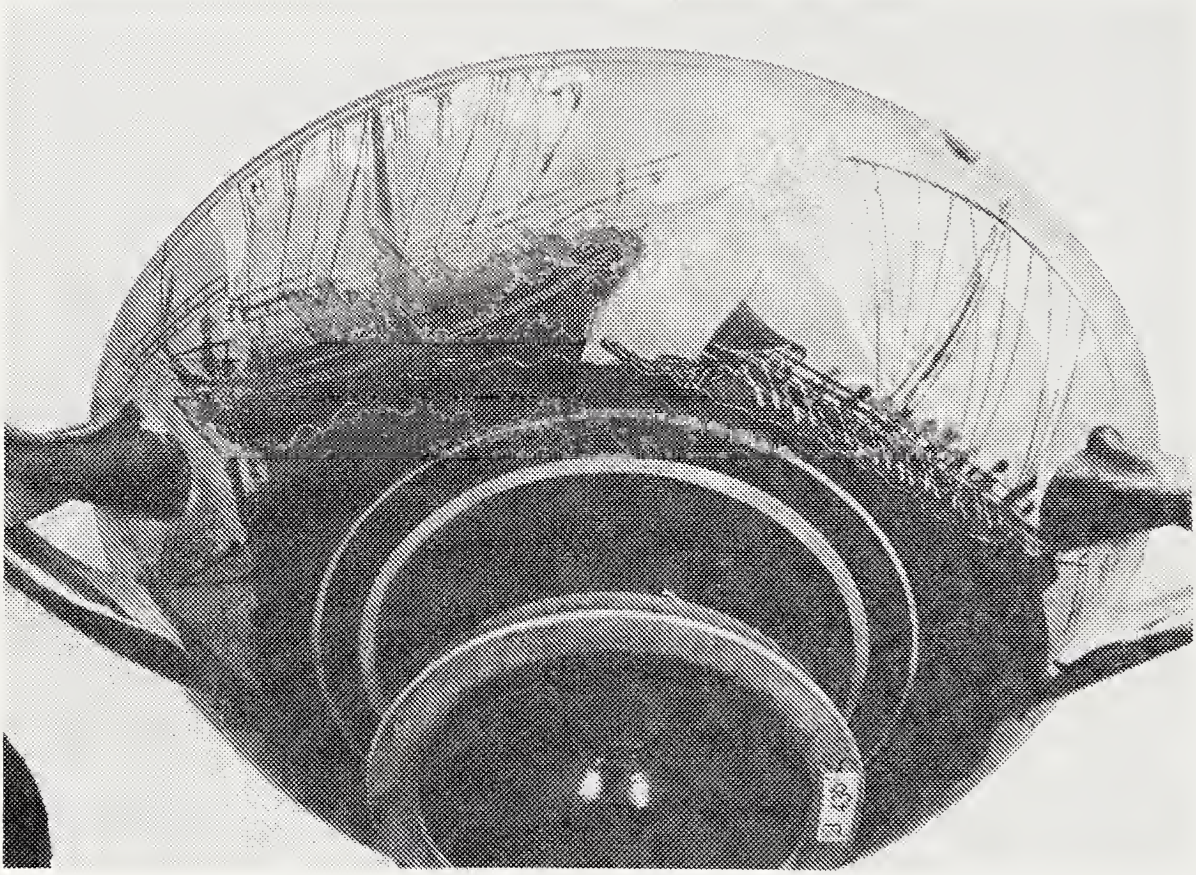


Plate I A Greek merchant vessel encountering a warship with oars at two levels under sail but with oars manned. The merchantman, riding high, is brailing up her mainsail. The hull is fitted with a permanent bulwark further raised by a spray-screen (canvas or wickerwork). A black-figured attic "Kylix" of the Leagros – group around 510 B.C. British Museum Inv. Nr. B 436 – Archaic 3.

Period: Greek Classical

Class. 1 Mural painting in Tarquinia rock-tomb, the 'Tomba della Nave, Etruscan work probably influenced by Greek-Ionian technique 490–480 BC. A large-sized cargo-ship with a mainmast well stayed and carrying a sail and a foremast slightly tilting forwards. The standing and running rigging is difficult to interpret. The hull is shown as fully visible, as if beached. The mural is now transferred and restored. The Tarquinia Museum.

Class. 2 *Askos* in the form of a ship's hull fitted with a handle in black Campanian or Etrusco-Campanian were. (Plate II) Early half of the fourth century BC. Excavated from tomb 17 a in Spina. The hull shows a curved stern profile but a bow with a ram like-beak. Three external horizontal rubbing-strakes line the hull. Alfieri Fig. 3.

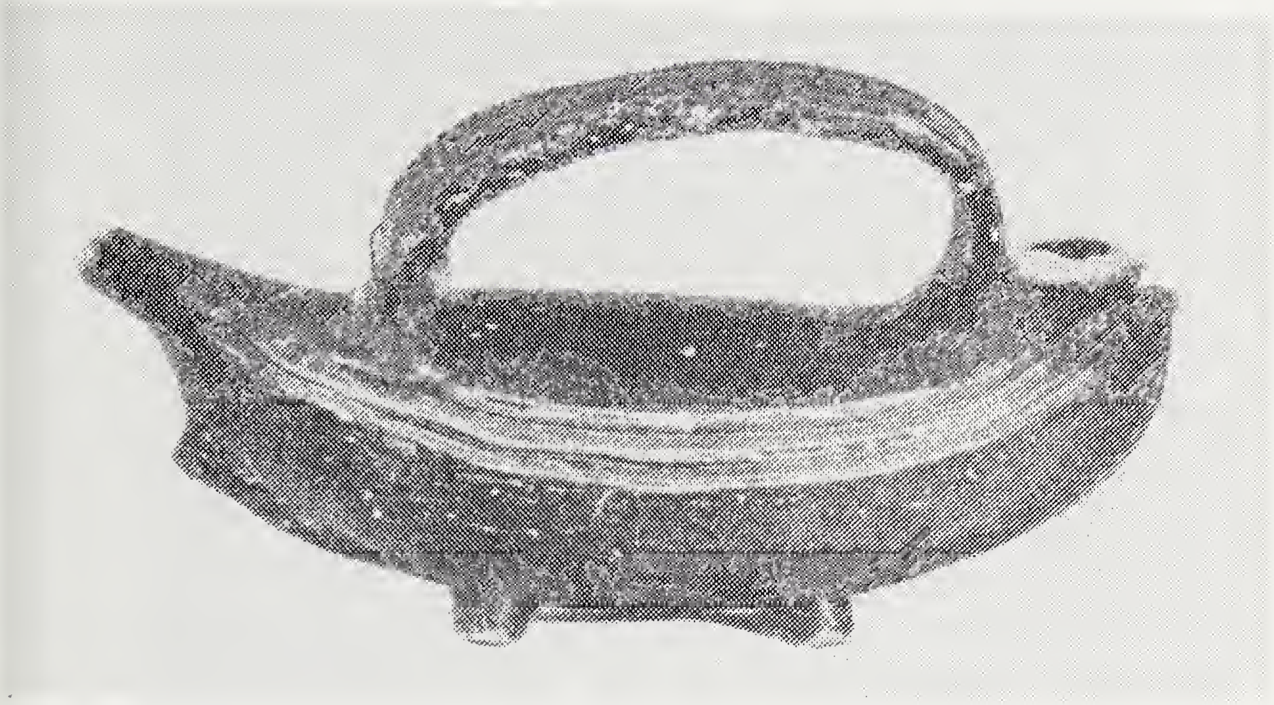


Plate II A Greek merchant vessel shown in the form of a black coloured campanian – or etrusco-campanian – "Askos" (A waterpan). Early 4th century BC. Found in Spain. Museo Archeologico Nazionale, Ferrara. – Class. 2.

Period: Hellenistic

Hell. 1 Relief on the short end of a stone sarcophagus from Sidon (Plate III). Mid-first century BC. A large-sized sailing cargo-ship corresponding to the standardised type (the *corbita)* of the first century AD, carrying a main rigging and the artemon rig. The hulll shows the curved stern profile ending in the *cheniskos* (swan's head). The roomy deck-house is fully developed. Beirut. Contenau Fig. 10 F L'Illustration, Fig. p.34.

Period: Imperial Roman

Rom. 1 Tomb-relief in the Via delle Tombe, Pompeii: Naevoleia Tyches tomb. First century AD. A large-sized cargo-ship with main rigging and artemon rigging. The mainsail is furled by the clewlines and the crew is going aloft to belay. The sternpost ends in the *cheniskos.* At the port steering-oar a female figure stands of larger than human scale, probably Venus Pompeiana ? Maiuri Tav. III d.

Rom.2 *Ara* with low reliefs, excavated close to the Tiber. Probably of early imperial date. A ship's hull without oars or rigging but with one steering-oar. A goddess (Cybele ?) is seated in a four-wheel carriage on the deck. A deck-house is shown. To the right a standing female figure in Roman attire handles the bow-hawsers. (Claudia Quinta frees the grounded ship of Cybele in the river Tiber). The hull resembles that of an oar-propelled ship. Museo Capitolino. Cook *Cybele* Fig. 8.

Rom.3 A fragment of a mural: Regola I Insula 13 Nr. 10 in Pompeii. The ship of Lesbianus: a small-sized sailing merchantman with two steering-oars. The stern timber ends in a *cheniskos.* A bow timber is extraordinarily steep. The mainsail is shown higher than usual. A goddess (?) of larger than human scale handles the steering-oars. Maiuri Tav. IV.

Rom.4 A graffito (Plate IV): the cargo-ship *Europa* scratched on the front wall of a house in the Via dell' Abbondanza, Regola I Insula 17 Nr.3 in Pompeii. This graffito presents skilfully a large-sized merchantman of the *corbita* type, under sail. The standing rigging and the clewlines are well represented. The artist indicates duly the joints in the planking and in the keel-timbers, since the underwater hull is shown exposed. The horizontal rubbing-strakes are given in detail.
Maiuri Tav. II

Rom.5 Oil lamp of the 'lucerna a disco' type: the circular disk depicts a cargo-ship with furled mainsail approaching a lighthouse. One figure in the stern is represented on more than human scale. The details of the foredeck as well as of the work being carried out there are obscure.
British Museum Inv. Nr. 532.

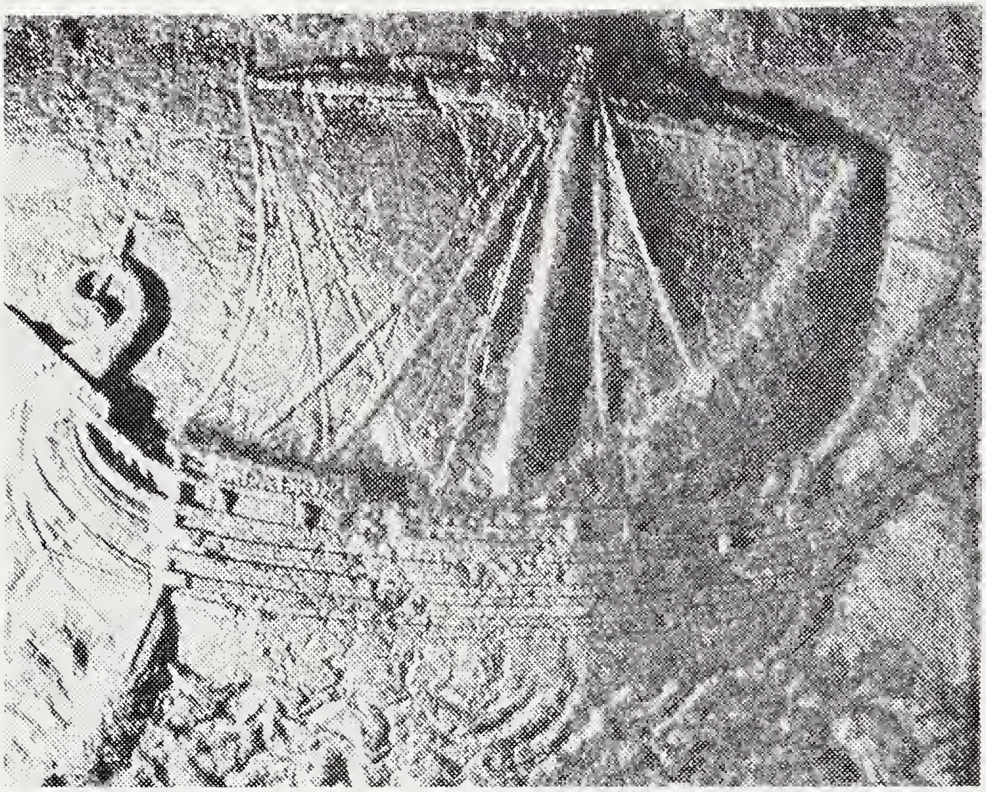


Plate III Relief on the short end of stone sarcophagus from Sidon. Excavated by the French scholar Contenau, dated to late Hellenistic Epoch. This apparently true representation of a big sized carrier coincides with the Alexandrian wheat-carriers of the early empire – or belongs to this category, in as much as secondary details such as deck-house rails, the "Cheniscos" (Stern timber) etc. are similar. The ship floats too high. – Hell. 1.

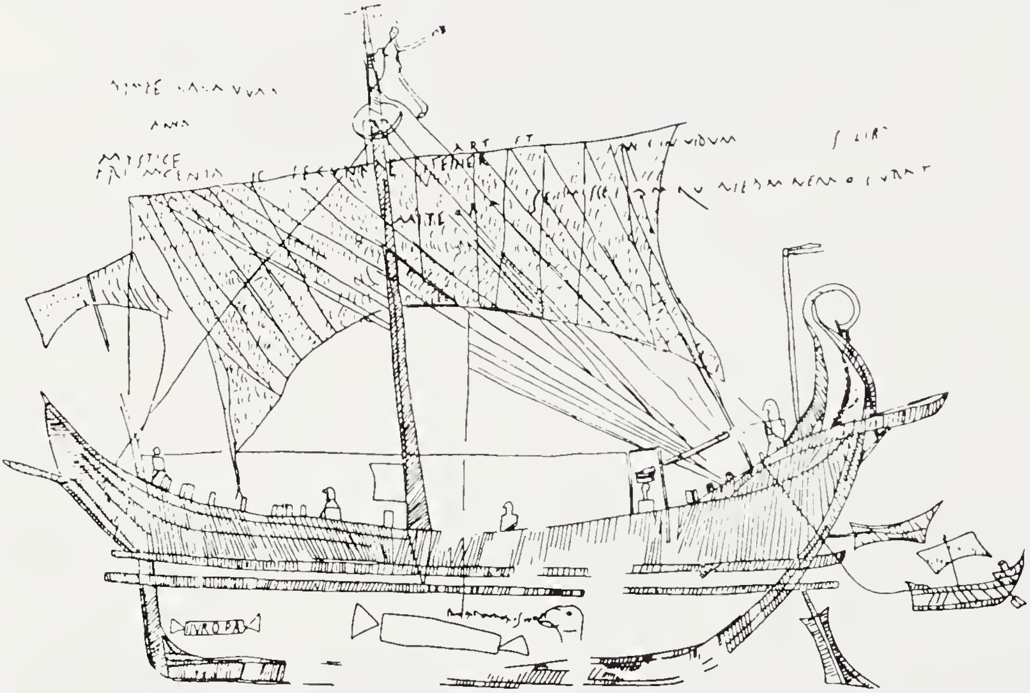


Plate IV A 'Graffito' from Pompeii. Reg. I. Insula 17.Nr.3. Showing a sailing cargo-carrier of *"Corbita-size"*: The "Europa". OBS. the valuable indications of carpentry in the forefoot, the heavy rubbing strakes along the outer planning, and the belaying of brailing ropes in front of the helmsman – Roman 4.

Rom.6 A graffito (Plate V): the cargo-carrier *Tarros Felix* scratched on the wall in the substructure of the Domus Tiberiana on the Palatine in Rome. The ship is shown under main- and artemon-sails. The bows are shown rising only a little above the flush deckline with heavy vertical bollards indicated. Only one steering-oar is visible. Not published.

Rom.7 Bases for columns sculpted as ships, now fragmentary. Excavated from the *Portus Augusti*. The bases represent the broad, flat hulls of cargo-ships with two horizontal rubbing-strakes, protruding 'bridges' for steering-oars and a broad clumsy stern with the sternpost rising steeply. The visible portions of the deck are covered with heavy battens athwartship.
Museo Nazionale, Museo Torlonia Rome. Le Gall Figs 1-7

Rom.8 Reliefs (metopes ?) depicting sailing cargo-ships: Museo Archaeologico Nazionale, Aquileia 3rd century AD. The ship is fitted with a single mast carrying a square chequered sail. Stays, braces and clewlines are very coarse. The bow shows a beak, the stern has an *aphlaston* or *aplustre*, like an oared ship, curving forward. A heavy bollard is shown forward of the mast. Two rubbing-strakes are shown.
Alfiero Fig.4.

Rom.10 The *portus* or Torlonia relief from the Roman *portus* area (Plate VI): in the Museo Torlonia. 3rd century AD. Two ships of the *corbita* type are shown within an artificial basin against the background of a light-house, a triumphal arch and various mythological figures, Neptunus, Liber etc.
Uccelli Fig. 289, Casson Pl.12, Meiggs Pl.XX.

Rom.11 Floor mosaics of black and white *tesserae* from Ostia dating to the reign of Commodus (180–192).
(a) in front of a brokers' office (*navicularii syllectini*), two sailing *corbitae* with mainmast and artemon. One has a bow curving forward and upward, one a ram-like beak.
Meiggs Pl.XXIV b, Casson Pl.11 b
(b) in front of a broker's office (*Karalis*): a cargo-ship carrying main- and artemon-rigging and a beak-like bow. The ship is flanked by two grain-measures (*modii*). Text: *navi (cularii) et negotiantes Karalitanii.*
Meiggs Pl.XXIII
(c) the operation of transferring *amphorae* (? wine) from a seagoing carrier to a sailing coaster or barge of the *navis codicaria* type (Plate VII).

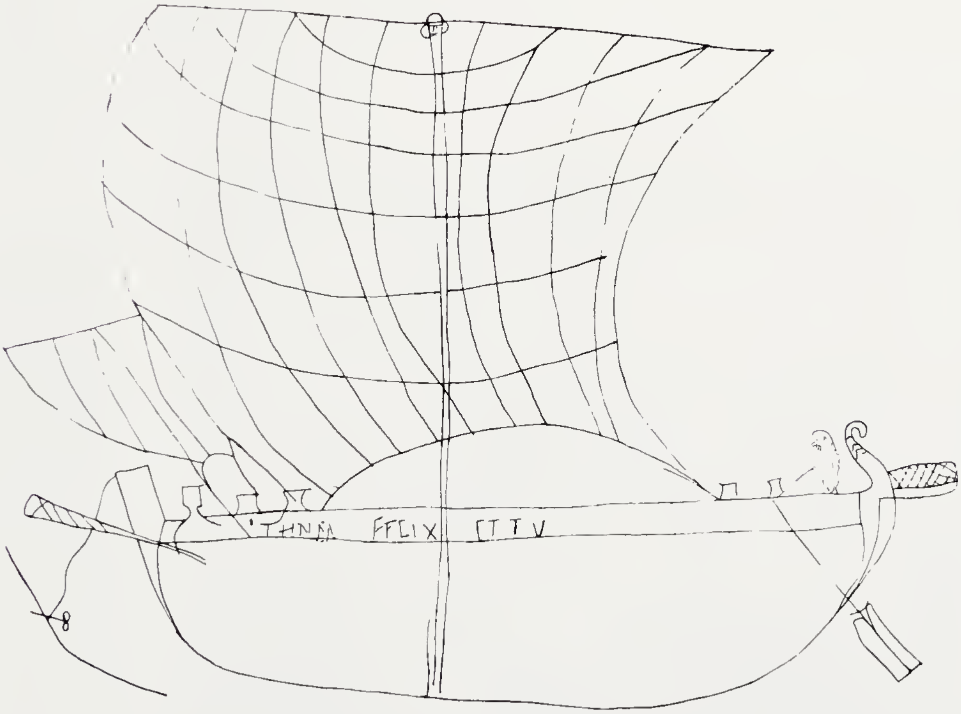


Plate V A 'Graffito' from the substructions of the Imperial Palace "Domus Tiberiana" on the Palatine Hill, Rome. The naive scratching shows a sailing cargo-carrier the "Tarros Felix" running before the wind. OBS. The heavy bollards fore and aft and the small balcony protruding aft. – Roman 6.

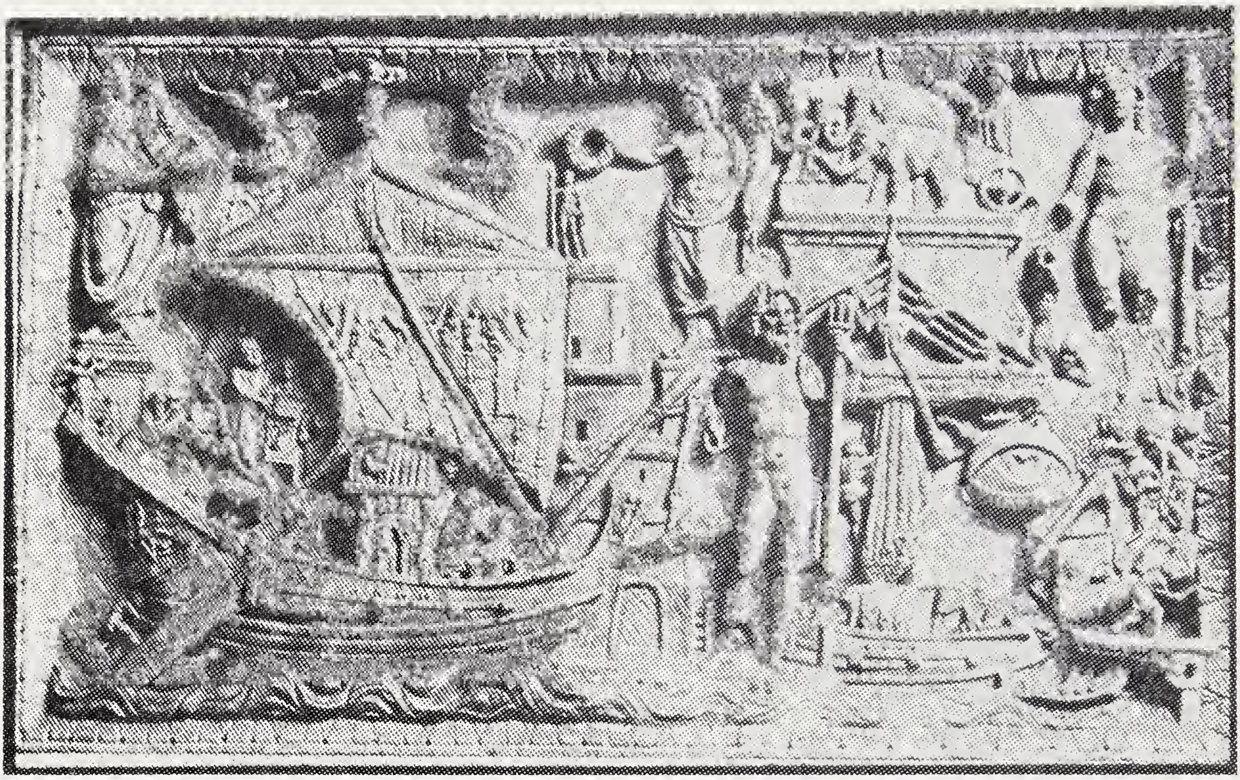


Plate VI The S.C. Portus – relief, recovered from the Portus-Augusti area Abt AD 200. (The relief is partially restored), Museo Torlonia, NR. 430. Two carriers of the Corbita – category moored bow to jetty in a basin. In the background are a lighthouse, various details and symbols, an elephant-quadriga on a podium etc. The ship to the right is discharged along a gangway, on the left an offering is carried out on the roof of the deckhouse. This is the most detailed representation of sails and their gears, standing rigging and the methods for setting up shrouds etc. – Roman 10.

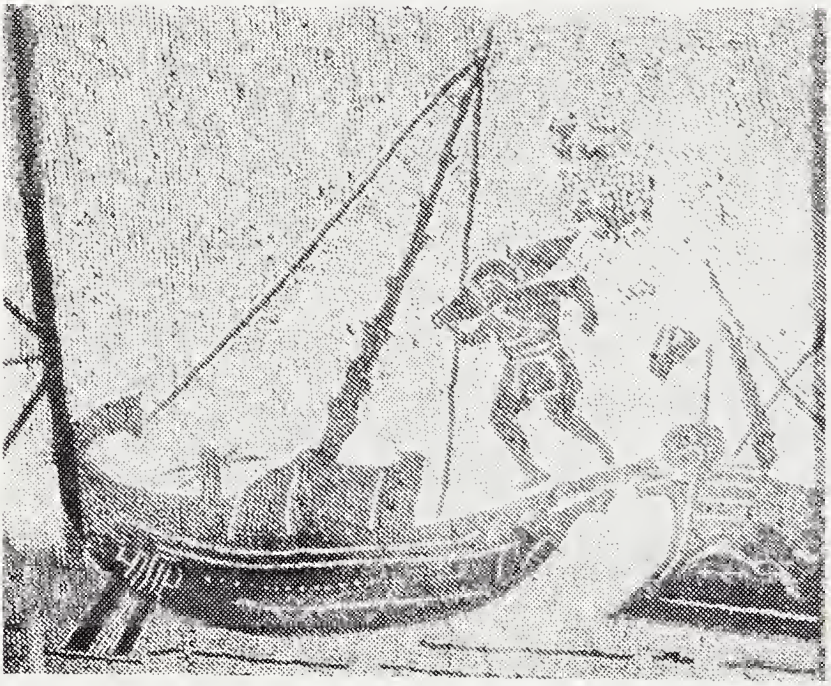


Plate VII
Trans-shippment of goods in *amphorae* from a seagoing carrier ? to a coastal lighter along a gangway laid between the hulls. The hull is fitted with double steering oars, a detachable mast equipped to allow deckhands to climb with the towrope, and a capstan located aft of the mainhatch. A fragment of a roman floor-mosaic in black and white. Piazzale delle Corporazioni, Ostia. – Roman 11C

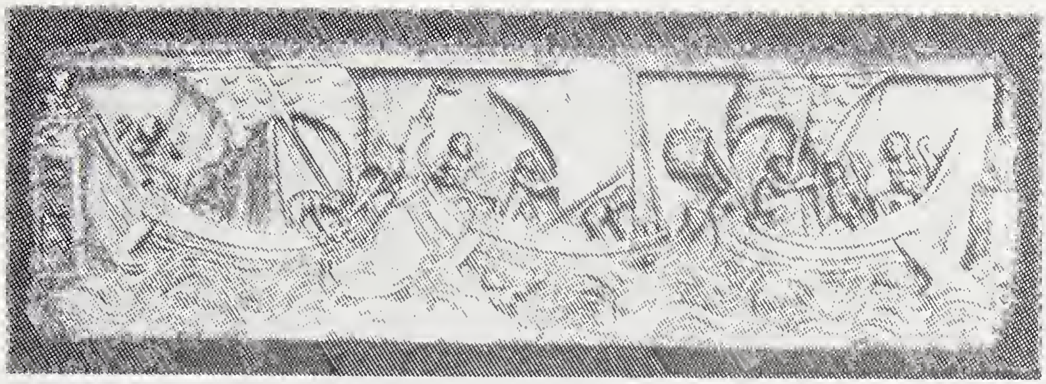


Plate VIII Relief of an early 4th century sarcophagus from Ostia or the Portus-area. Ny-Carlsberg Glyptotek NR. 787. Ships maneuvring in the entrance to a port, most probably the "Portus". The situation is interpreted by L. Casson, "The Ancient Mariners" pp. 220–222. The ship in the center represents the sailing lighter (Navis Codicaria), the flanking ships are seagoing carriers. OBS. The scale of the crews represented typical to later Imperial art Roman 12.

Rom.12 Sarcophagus relief from Ostia: Ny-Carlsberg Glyptotek, Copenhagen. (Plate VIII). Early 3rd century AD. Three sailing cargo-ships (apparently sea-going ships and coasters mixed) manoeuvring in the entrance of an artificial port (*Portus ?)* flanked by lighthouses and turrets. The ships to the left and right carry the ordinary square-rig with artemon. The ship in the centre carries sprit-rigging. The forward and upward curving bow and the beak are both represented. The steering oar is similarly fitted in all the ships.
Casson Pl.13.

Rom.13 A relief built in the walls of the Cathedral of Salerno: 3rd century AD. A coastal barge with the main-mast collapsed forward to facilitate the unloading of cargo. The hull with bulwarks and steering oars is extraordinarily well depicted.
Uccelli Fig. 347

Rom.14 A fragment of a mural painting from a rock tomb in the Isola Sacra area (surrounded by two branches of the river Tiber) 2nd century AD: in the Vatican Museum (Plate IX). A *navis codicaria,* with the mast left standing, is handling cargo; actually, bagged grain is measured before stowage. The ship is named, its bow and stern protrude upwards and it has a deckhouse aft where the master or helmsman is standing. The details of the hull are not clear.
B. Nogara *Le Nozze Aldobrandine etc.* Fig. 4. p.65 and Pl.XLVI, Casson *The Ancient Mariners* Pl.14 b.

Rom.15 A floor mosaic from a private house on the Quirinal, now in the municipal collections on the Capital in Rome. The fragment shows the rear part of a cargo-carrier of large dimensions. The stern has a *cheniskos* and a flying balcony, a deckhouse with a seat for the helmsman. A part of the sail is shown with four clewlines running in rings. The starboard steering-oar has a hoisting-strap. Two wind-vanes are rigged as aids to the helsman.
Köster Abb. 41 (redrawn and unreliable).

Rom.16 A Roman *sestertius:* Commodus (180–192), BMC 588. Legend: PMTR P XI IMPVIII Cos VI P: Bottom: Provid.Aug A sailing cargo-carrier of *corbita* type. The mainsail is brailed; and the artemon mast stepped at 45°, carries a sail of small dimensions. There is a stern gallery. A heavy baulk or an outrigger(?) project to the starboard of the stemhead.

Rom.17 A bronze medal: Commodus (180–192); BMC Emp. IV Pl.40 I. Legend: VOTIS FELICIBUS. Left: a cargo carrier of *corbita* type under plain sails heads towards the lighthouse of Claudius (? Portus). Jupiter Serapis is seated in the stern. In front of the ship an oar-propelled barge and a smallish craft (*scapha*). Above the legend a cargo-carrier is depicted reducing sail.

Rom.18 A medal or a coin: Diocletianus or Maximinianus: RIC VI: VOTA PUBLICA TREVERI. A hull resembling the shape of a cargo-carrier with two masts of equal size. The forward mast is slightly tilted towards the bow. A figure seated in the stern represents the goddess Isis (?).

Rom.19 A mural painting in the catacombs of Calixtus still *in situ:* Mid-3rd century AD. A symbolic (and fanciful) representation of a sailing cargo-carrier. The hull is depicted as a crescent moon with the deckhouse as a set of descending terraces. The fitting of the steering-oars as shown is technically impossible. The main-rig is exaggerated in size with the sail hanging loosely in festoons. The artemon

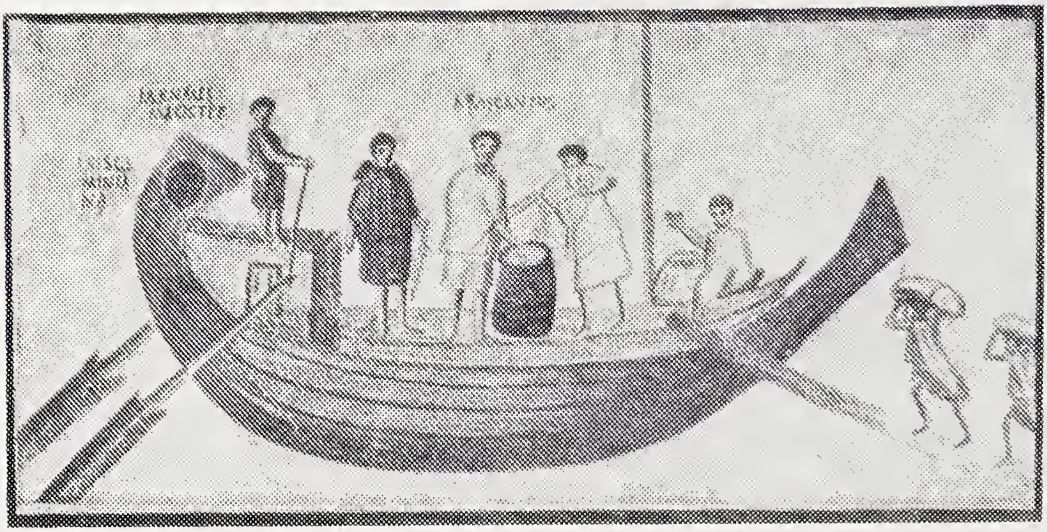


Plate IX The Isis Giminiana", a coastal lighter of the "navis codicaria" category, during loading of bagged grain. Official measuring is carried out amidship. The hull is fitted with a light mast lacking permant stays, with double steering oars and a sizeable deckhouse. A fragment of a Roman tomb-mural in secco technique from the Isola Sacra-Cemeteries Ostia. 2d century A.D. The Vatican Museum – Roman 14.

is depicted as stepped below and external to the stemtimber. A tiny mast is indicated on the high bulging stern, apparently acting as a staff for a burgee or wine-vane.

Rom.21 Scratchings on the bone handle for a tool, a dagger or sword, found during dredging operations in the river Weser. 3rd Century AD: barbarian work of an impromptu nature depicting naively a Roman sailing cargo-ship with main- and artemon-rig but also with oars in position. Within the raised stern there is a deckhouse and a helmsman standing on the roof.
Köster *Studien* Abb.16.

Rom.21 Late Roman polychrome floor-mosaics excavated in Tunisia at Hadrumetum (mod. Sousse) and Themetra mid 4th century AD. These large compositions show sailing and oar- propelled vessels as well as hybrids. These mosaics are referred to with the letter S = Sousse or T = Themetra (Plate X) with a running numbe in accordance with Foucher's practice.

S 1 A slender fast-looking hull, not built for cargo but carrying the regular two-masted rig of the cargo-carrier. One row of oars is operated from the main deck. The bow is fitted with a beak.
Foucher Fig.2

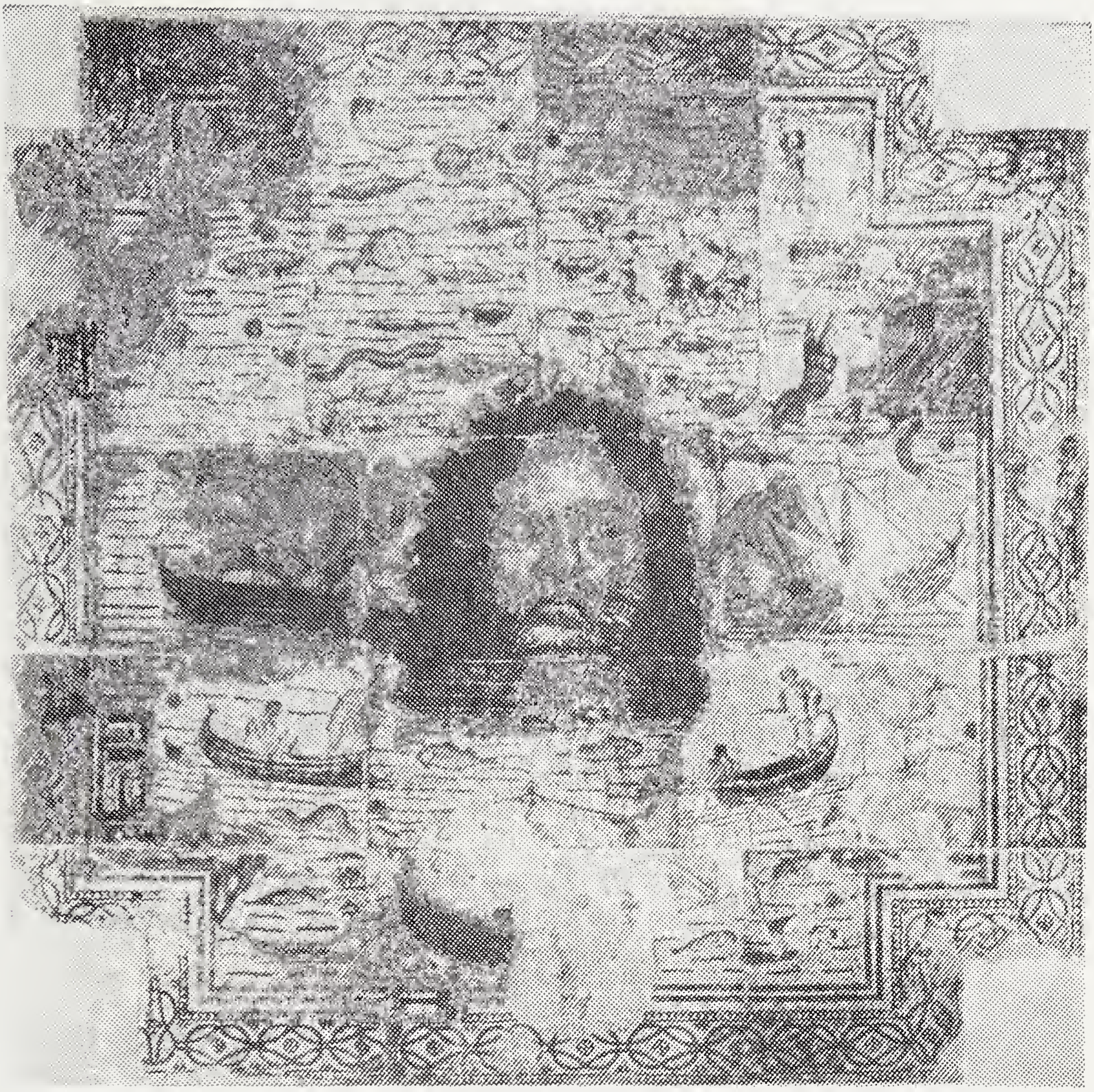
S 2 A sailing *corbita* or a coastal *navis codicaria* with her main mast lowered and supported by a crutc (Plate XI). The crew is shown on more than human scale. Cargo is being handled. To the left, on shore cargo is being weighed. The bow is of the beak type. The steering oars are shown protrudin from square openings (optically misrepresented). The whole representation is unclear.
Foucher Fig. 8.

T 2 A sailing cargo-ship with a beak bow. (Plate XII). The mainmast is lowered. The artemon rigging is accurately represented and includes stays. The square sail is furled to the yard and belayed in the best 19th century naval fashion.
Foucher Fig.12

T 3 A fragmentary representation of a cargo-carrier. The stern, with twin steering-oars is visible. Of the ship's fore part only the artemon yard with a furled sail is preserved.
Foucher Fig. 3

T 7 An extraordinarily well-preserved representation of a sailing cargo-carrier with a beak bow, a high-curving stern and horizontal rubbing strakes or wales stressed by the artist (Plate XIII). The ship carries the regular two-masted rig with an artemon sail of considerable size.
Foucher Fig. 4

T8 A sailing cargo-carrier corresponding to T 7 but with a sheerline showing less curvature (Plate XIV). The planked bulwarks are shown in detail as well as the heavy bollards on the foredeck. The bow shows



ate X A polychrome mosaic floor (of a Frigidarium) from the Roman Baths of Themetra, Tunis. Grouped around a large sized head of Neptunus are seagoing ships and boats, here labelled T. (Left of the head T-8, to the Right T-7). Musée National Du Bardo.

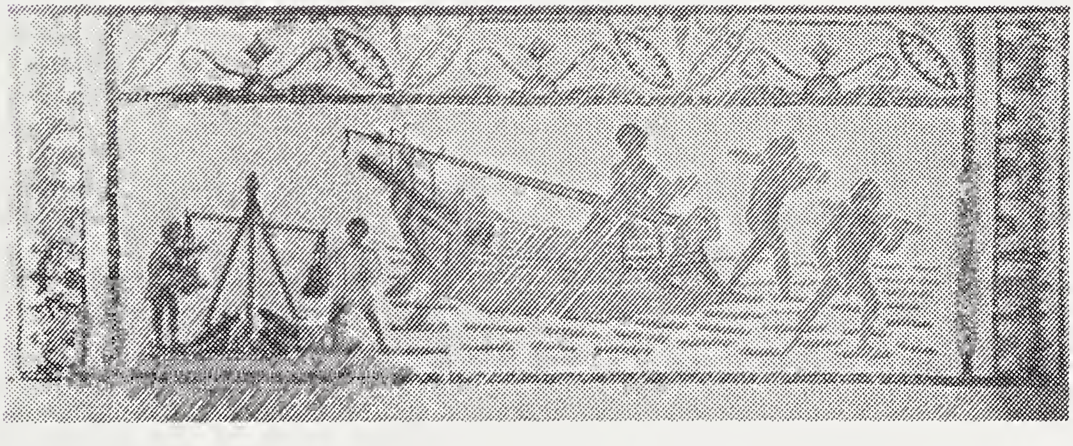


Plate XI A section of a floormosaic from Sousse (Susa) S – 2. Showing a cargoship with the collapsed mast resting in a fork. The picture illustrates the handling of lead ingots. OBS. The fitting of the steering oars and the error in perspective – Roman 21 5 –2

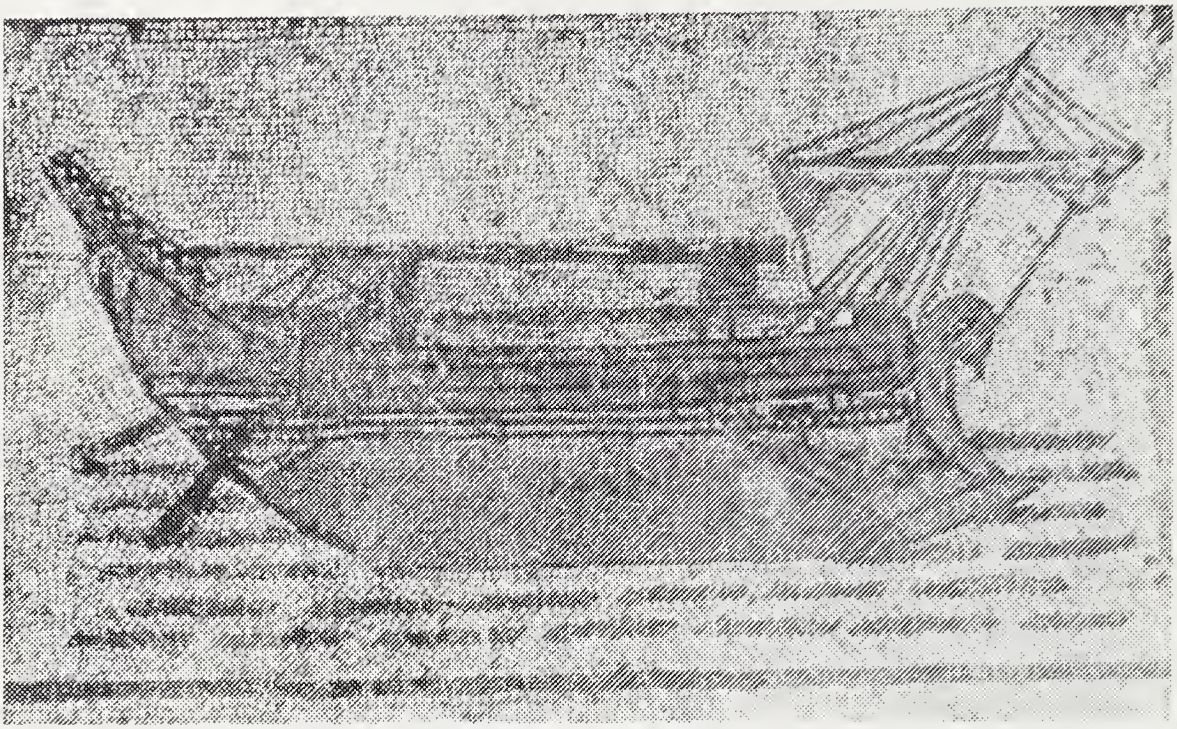


Plate XII A portion of a floor mosaic from Themetra, Tunis. T-2. A sailing cargo ship riding high and ligth with her mainmast collapsed but the artemon rig in working order and the sail properly belayed in 19th century fashion. – Roman 21. T-2

a beak but is logically timbered. The stemhead is finished off with a volute. The mainsail is high and efficient. The artemon mast, tilting at about 45°, carries a square sail of considerable size. The mainsail is fitted with bowlines carried well forward.
Foucher Fig. 5

Rom.22 Relief decorations on an early Christian sarcophagus depicting the maritime adventures of Jonah. They show naively a sailing cargo-ship with the seagoing rig, but with the hull and other details poorly represented. All stays are lacking. The mainsail including the triangular topsail (*supparum*) are described in detail, the seams being shown as double lines stitched over.

Rom.23 Wall mosaics in San Apollinare Nuovo in Ravenna placed on the clerestory wall. Early 6th century. Three cargo ships with bows and sterns raised and fitted with a single mast. The scene is given as the *classis* adjacent to Ravenna. The representation lacks any documentary value.

(ii) Commentaries to the Ship-Representations

General comments:

A part of the material referred to above was already known to scholars in the late nineteenth century, but the bulk was revealed by archaeological activity in the present century. This latter part constitutes what is in fact the material of importance for the understanding of nautical structure. The older material was to a very limited extent noted by scholars in the nineteenth century which was the period when interest was focussed on the oared ship. As a result this material is of little interest to us. The sailing cargo vessel was not of interest being referred to in excerpts from ancient authors only in passages which mentioned ships of luxury, huge size or of special design, such as those built for the transport of obelisks. Interest in Hellenistic and Roman foreign trade and seafaring is of recent date. Torr, in his scholarly presentation of the nautical aspects of antiquity mentions the sea-going carrier *en passant* in roughly one hundred lines only[5]. Yet in an appendix[6] he lists various types of such ships, giving their characteristics and origins; and, as is his practice, makes critical comments on the relevant

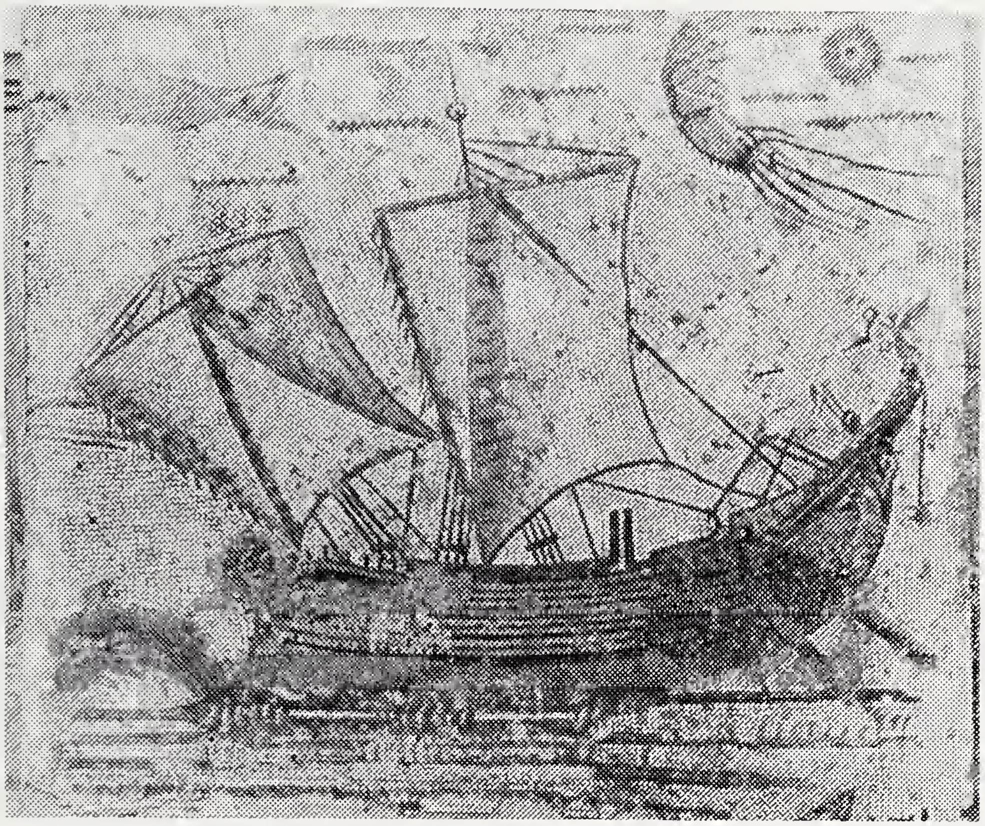


Plate XIII A section of the Neptunus-mosaic from Themetra the T-7 shows a two masted carrier with an exaggerated sheerline riding queerly in the water. The artemon sail is sheeted aback. OBS. That the tillers of the steering oars are pointing sternwards indicating the place of the helmsman to be high up in the stern – Roman 21. T-7

literature and sources. The illustrations he provides, being mainly drawings of the originals, are of poor quality and often do not accurately represent the originals. The provenance as well as the location at the time of these representations are noted.

Material from early antiquity

The sea-going cargo ship represented in the *krater* of Aristonothus (Arch.1) has not been noted as evidence for the existence of large-sized heavy carriers (possibly fitted out by communities or city states ?) in the late seventh century. The carpentry employed in the bow, differing entirely from that used in the oared ship, resembles the principles of Phoenician merchantmen, a fact which has seldom been stressed. Morrison and Williams (who regard the ship as a warship) describe the bow as a 'down-pointing ram'[7] not structurally consistent with the upward-rising bow, and then with added timbers. This method of carpentry is further demonstrated by the representation of a sailing cargo ship (Arch.3) on a black-figures Attic *kylix*, showing a fine concave curve from the keel-timber upwards, achieved by the addition of timbers. The profile strongly resembles that of a nineteenth century coastal schooner. The painted eye here takes the place of the carved 'scroll'. The double horizontal rubbing-strakes, strengthening the top-sides as well as protecting them from wear, meet in a point above this wooden 'snout'. In the comparison with a nineteenth century hull only the bowsprit is missing. The hull, riding high, shows a pleasing sheerline and a buoyant stern, in many respects resembling the design of the contemporary oared-ship. This vase-painting was for a long time considered unique and did not convince scholars of the existence of larger merchant tonnage. A new situation arose with the discovery of the Etruscan chamber-tombs in Tarquinia, called the 'Tomba della Nave' and dated about 480 BC[8], in which a mural represented a two-masted ship with a hull very much resembling the aforementioned Greek cargo-ship[9]. Differences are noticeable in the dimensions. The Etruscan hull shows a smallish, apparently raised (?) forecastle fitted with a planked rail or bulwark. Here also the straight bow-profile is turned in a concave curve, resembling the 'clipper bow', byt the addition of timber.

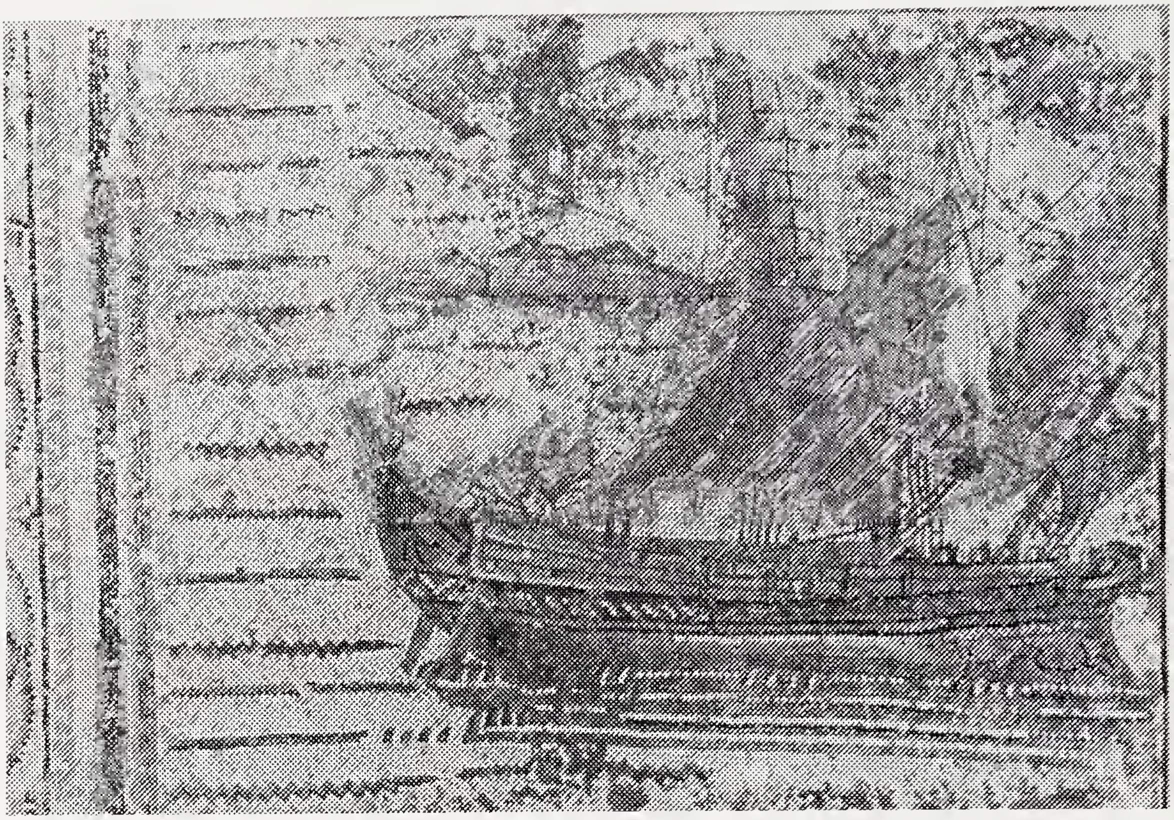


Plate XIV A section of the Neptunus-mosaic from Themetra the T-8 showing a big sized cargo-carrier under full canvas in ligth winds. This is the most detailed representation of a merchantman from late antiquity which refers especially to the sails and the running rigging. OBS. The bowlines of the mainsail carried to the artemon-mast. – Roman 21. T-8

The naive mural painting does not allow a detailed study of shipwright's work. In his early presentation of the ship Lionel Casson[10] concentrates on the peculiar rigging leaving the hull aside. The rig will be analysed later. (Chapter VI).

Material from the Hellenistic Epoch

From this scarce and inadequate material we are brought abruptly to the large-sized, fairly standardised, merchantmen of the Hellenistic period and of the early Roman Empire. In fact we leap a gap of almost half a millennium in which, although material culture is flourishing, nautical information is almost entirely lacking. There are however reasons for assuming the existence of highly developed ship-building techniques in this obscure period, at least within the sphere of the royal navies of the eastern Mediterranean. But we are unfortunately extremely ill-informed about seafaring and shipbuilding within this area during the three centuries of Hellenistic rule. The situation was not improved by the interest in warship construction exhibited by the competing Macedonian dynasties.

The short end of a sarcophagus from Sidon (Hell.1) is dated to the 1st century BC, probably to the second half of the century. The ship represented should be seen as the tool of a Hellenised seafaring activity carried on in the Phoenician cities of the Levant[12]. As a type this ship in every respect corresponds to the sailing cargo-ship of the early Empire. There is reason to think that this type was fully developed already in the civil wars of the 1st century BC, as well as to look for its origins within the eastern basin of the Mediterranean. It should be regarded as the outcome of a long nautical development, one stage of which is represented by the mural of the 'Tomba della Nave' in the 5th century. The extreme slowness of the evolution should be attributed to the conservatism of professional seafarers and builders. As positive forces in this evolution we may look to the active capitalism of the Macedonian dynastics associated with trade monopolies and long-distance trading.

Where archaeology fails scholars have again turned to the literary sources, but unfortunately these supply us with only haphazard and doubtfully accurate notes and anecdotes, categories of ships, names and facts concerning carrying capacities, which seldom could be reasonably translated into modern measures[13]. The authors of antiquity seldom understood the language and every-day questions of shipping people and have been fascinated by exaggerated figures and fairy-tales, frequently mixing up contemporary matters with facts from the distant past. Typical of such authors is Athenaeus, writing in the third century AD. In the *Deipnosophistai* he quotes various ancient Greek authors, among others the apocryphal Moschion, mentioning the mammoth 'Syrakosia-Alexandris', built to the order of Hieron II of Syracus[14]. This ill-fated giant of antiquity[15], launched only through the genius of Archimedes, was described in a series of apparent exaggerations which were most probably increased by oral tradition. A typical trait of these authors is the interest shown in luxurious interiors and expensive materials, while no attention is paid to dimensions, construction, rigging or facts about the crew and the functions assigned to them. The same could be said of certain professional authors of imperial Rome, who uncritically repeated borrowed facts but seldom went to see for themselves. We cannot build a reconstruction of the cargo-carrier of the Hellenistic centuries on literary references. On the other hand underwater sites and wrecks, first and foremost the wreck of the Grand Congloue[16], supply us with some of the facts necessary for the reconstruction of the sailing carrier of the 3rd and 2nd centuries BC.

Material belonging to the period of the Empire

Generally we may conclude that the large-sized carrier of the Early Empire is a fairly standardised Mediterranean type[17]. The ship represented on the sarcophagus from Sidon is almost identical to the *corbita* of the 1st century AD. Ship-building in the eastern Mediterranean apparently developed along identical lines and principles during the Hellenistic centuries. Criteria for separating Phoenician, Egyptian, Greek or Etruscan vessels cannot be defined. From literary sources we may possibly derive the conclusion that the Phoenician sea-going ship provided the model for Greek vessels of the 9th and 8th centuries but it is also possible that Phoenician shipbuilders took as their models the ships of the sea-minded Minoan civilisation[18]. Italian scholars stress the queer shapes of archaic Etruscan oar-propelled vessels, as they are observed in objects of art, and consequently point to individual trends[19]. These peculiarities should however be seen as exaggerations or as the result of a lack of nautical knowledge by the artists involved. International shipping seldom admits national peculiarities, which are in any case eroded by the necessity to meet the demands of navigation on the high seas. Yet we may perhaps exclude from this generalisation Egypt before the Ptolemies. It appears that during the great Persian wars almost similar ships were built by both sides[20]. The situation was the same between the Carthaginians and the Sicilian Greeks, and between the Italian, Greek and the Etruscans. When, about the 3rd century BC the Hellenistic world appeared to have reached its full development, technical concepts were generally common.

At about this time it seems likely that the eastern Mediterranean was the scene of seaborne trade and shipping activity carried out in the Greek language and based on Greek monetary standards whether by Cypriots, Syrians, Egyptians or Macedonians. The sailing cargo-carrier which we meet in relief sculptures or in mosaics during the early Empire was a product of the eastern Mediterrancean but was representative of the whole of it as the combined heritage of a thousand years of development.

At this time, during the early Empire, we find frequent representations of sea-going carriers as well as of the famous heavy wheat-carriers. By comparative studies of mosaics in particular we may assume the parallel existence of the different sizes, probably developed for the various types of merchandise[21]. Ship representations showing numerous vessels are seldom true to scale, the standard for our notions of the relative dimensions being insecure[22].

In the shadow of the large-sized seagoing carrier we discover a smaller variant, fitted with a single mast usually shown lowered (either forwards or sternwards) and fitted with rungs to permit the crew to go aloft. Such a craft is the Italic coaster, called *navis codicaria*[23] which exhibits almost all the characteristics of the full-grown sailing carrier[24], the low ratio of breadth to length, the rounded shape, the fitting of steering oars as well as a number of negative characteristics making the craft a poor sailer[25]. The rigging shown seems to be an improvisation, stressing the original character of the hull as a river lighter for towing, or a barge proper with an auxiliary rig of poor design. As to overall design or build we may apparently treat the sea-going ship and the coaster/river craft on similar terms since we have no reason to assume different methods of construction in large – as opposed to small-sized hulls. In this respect we may turn to the principles of ship's-carpentry already stressed by us. We are constantly reminded of these principles when studying the scantlings of the wrecks investigated by underwater teams capable of carrying out proper measurements. As to the oar-propelled ship the carpentry as well as the scantlings are still based on hypothesis. On the other hand we are fairly well-informed about small-sized hulls for river and harbour use, thanks to various representations[26]. Recently the picture was clarified by the recovery of the hull-remains of shallow craft of this kind, mainly undecked river-barges. These however are not the concern of the present study, although the structural details observed must be taken into account here.

The sail-propelled cargo-carrier of late antiquity had a broad, fairly shallow, hull of the double-ended type. The stern was raised, rounded and buoyant, while the bow was sharper with a convex cutwater curving outwards and upwards. In parallel with this type we find carriers with a bow shaped like the beaklike snout or ram finishing the forefront of the oared vessel. Structurally this type differs totally from the latter; it differs also as to buoyancy and general seaworthiness since the beak was inferior in these respects. Common to both types of bow was a cutwater and bluff underwater sections with a minimum of lateral resistance, i.e. not shaped for windward work. Fairly little is known about underwater hull-sections, but by putting together all the known facts it is possible to derive some hypothetical midship-sections.

As to the actual structures and ship's-carpentry, the representations mentioned are not very informative. We may observe that bow-timbers were of heavy dimensions, so were deck-beams and the longitudinal rubbing strakes. The deck-beams were carried through the planking with square heads visible, thus constituting binding elements in the structure. As to frames, planking, longitudinal or transversal binding elements, nothing further is found in the representations.

From the tomb-stelē of Longidienus,in the Ravenna museum, we have full evidence that hewn frames were inserted into a planked hull, as shown by Casson[27]. The interesting graffito from Pompeii, depicting the *corbita* Europa (Rom.4), is actually a naive work, but yet a most informative one, showing in their position the basic longitudinal timbers of the hull, the assemblage of the bow-timbers with a reliable-looking knee and a joint, the clever structure of the bow being composed of numerous pieces bolted together[28], and the extremely heavy rubbing-strakes, the position of which points to their function as longitudinal strengthening elements.

From the interesting ship-like column-bases in the Museo Nazionale and the Museo Torlonia[29] in Rome we are able to derive important facts viz. a structural main deck protruding outwards and laid on deck-beams prolonged (or possibly consoles = knees), a feature which can actually be seen in the Lake Nemi hulls and further confirmed by some of the Themetra mosaics. The peculiar transverse timbers, laid as a double deck of heavy battens, shown in the bases above-mentioned, should in the writer's opinion be understood as a temporary precaution against extraordinary stress, possibly to enable the carrying of the column actually stepped on the base.

The sarcophagus from Ostia, now in the Glyptothek at Copenhagen (Rom.12), showing three cargo-vessels manoeuvring, contains numerous important pieces of information concerning planking, rubbing-strakes and decks. Of utmost importance is a bulwark with heavy stanchions most convincingly shown.

Unfortunately the abundant material of floor mosaics in black and white seldom supports us with detailed information as to design or structure, since the plain silhouettes cannot present a three dimensional representation. On the other hand interesting details are found in the polychrome floor mosaics from Themetra (Rom. 21 T 3, 7 and 8).

Basically the cargo-carrier, apparently irrespective of size, remains unchanged from the 1st century BC to the first half of the 4th century AD, possibly until the end of that century. Documentation in the succeeding centuries, mainly based on mosaic representations, is unreliable and sporadic. From the time of Constantine the general quality of works of art declines. Further we observe a lack of observation of details by the artists. Works are copies apathetically or themes repeated along accustomed lines. Thus, as far as technical matters and details of ships is concerned, ship-representations are most unreliable in the late Empire. There is reason to believe that late ship-representations, e.g. the important Tunisian polychrome floor mosaics, may be late copies of 1st or 2nd century artistic patterns[30], in cases where we find elements from the oared ship, more popular among the artist's clients, playing a part in the themes. Thus we encounter difficulties in finding material relevant to the cargo-carrier after the division of the Empire, and particularly at the time when the Germanic pirates were harrassing trade in the Mediterranean area. In spite of the breakdown of imperial administration and the diversion of trade routes towards the new capital on the Bosphorus, there is evidence to show that wheat was still carried to Rome by sea until the time of Gregory the Great, a fact which implies the continued existence of the grain-carrier. Yet our information about these late vessels is insignificant. The early wall-mosaics at Ravenna lack documentary value.

The present study covers in principle only the period from the 4th century BC to the establishment of the new capital of Rome on the Bosphorus.

NOTES TO CHAPTER II

1. Rostovzeff *The Social and Economic History of the Hellenistic World* stresses the general lack of sources on economic, mercantile, and shipping matters.
2. Meiggs op.cit. Imperial control pp.298-310, the Guilds pp. 311-336.
3. Minoan gems from the island of Crete show crescent boats with probably religious associations. A single mast is placed in the middle. Compare Cycladic boats or ships with a vertical bow and a fish carried on a staff as a religious symbol.
4. Not relevant to our studies are Cyprian objects in the British Museum: ship-models in painted terracotta from Amanthus (Cyprus) representing large-size, high riding hulls with raised stern-galleries, also undecked craft with a bow curving upwards, others fitted with the forefoot of the oared vessel.
5. Torr *op.cit.* pp.23-30.
6. Torr Appendix pp.105-124.
7. Morrison and Williams *op.cit.* p.75. Comp. Halldin *op.cit.* Fig.46, a graffito from Utica.
8. Mario Moretti *Tarquinia, la Tomba della Nave* presents a rock tomb in the Monterozzi district at Tarquinia (Nr. 238) excavated by the authority.
9. Moretti op. cit. Plates 18 and 19.
10. L.Casson 'The Earliest Two-masted ship' Archaeology Vol. 16 2 (1962.
11. Tarn *Hellenistic Military and Naval Developments* pp. 122-152. Casson *The Super-galleys of the Hellenistic Age M.M.* Vol. 552 (1969).
12. This sarcophagus was found in the hypogaeum during French excavations in Sidon in 1914 directed by Georges Conteneau. Syria 1 35 Fig. 10 (1920). The ship symbolises the last voyage of the deceased.
13. Köster *op.cit.* Grösse der Handelsschiffe, pp. 158-166. See also Casson The Isis and her voyage pp. 51-55, *id. The Ancient Mariners* pp. 214-216.
14. Persson Die Hellenistische Schiffsbaukunst und die Nemischiffe *Opuscula Archaeologica Vol. 1* pp. 132-146 (1935).
15. The mammoth ship, exceeding normal dimensions and thus unsuited for normal terminals, had many ill-fated parallels in the age of growing industrialism: the wooden-built U.S. clipper 'Great Republic' of 1853 or the British iron-built screw-wheel steamer 'Great Eastern' of 1858.
16. See chapter 1 note 17.
17. Giuseppe Cultrera 'Nulla al mondo si ha di piu cosmopolitico dell' architettura navale. E la ragione é evidente: le navi si muovono e, attraverso il mari, approdono nei porti e negli estuari dei paesi piu disparati: ogni novità, ogni progresso viene davunque osservato e facilmente sequito'. *Notizie degli Scavi* (1932).
18. As to Minoan maritime traditions, see Köster op. cit. p. 70.
19. Paglieri, op.cit., treats philological and archaeological material with a notable skill, but appears hampered in the area of nautical matters.
20. This refers to the Phoenician squadrons at the disposal of the Persian king. The ships of the maritime *poleis* of East Greece were in every respect the same as those of Hellas.
21. With Ptolemaic Egypt annexed to Rome the fleets of the Alexandrian shipowners were organised to carry enormous quantities of wheat, to be delivered as tribute to the conqueror, to Puteoli and later to Ostia. From the very beginning quantities were huge. During the last years of the reign of Augustus the Ptolemaic seaborne trade with India, using the Red Sea ports of Myos Hormos or Berenice, was reorganised. This trade involved running before the monsoons across the Indian Ocean and required a high standard of seaworthiness.
22. This refers to representation of the crew in particular who were frequently made larger than life. See the sarcophagus (Rom.12). The task is further complicated by the different scales employed by the artist for gods and heroes as opposed to mortals.
23. Seneca *De Brevitate Vitae* 13 4: naves . . quae ex antiqua consuetudine commeatus per Tiberim subvehunt codicariae vocantur.
24. See Rom. 11c, Rom.12, Rom.13 and Rom.14.
25. Compare three representations of a *codicaria navis* (Rom.11c, Rom.12 and Rom.14) especially the central vessel in Rom.12 (a sarcophagus from Ostia) with a sprit-rig.
26. Casson 'Harbour and River boats of Ancient Rome' *J.R.S.* (1965) PII (1) and (2) *The Illustrated London News* Nov. 1960: 'The Claudian Port of Ostia revealed during airport construction work'. Article not signed.
27. Casson 'Ancient Ship-building: New light on an old source'. TAPA Vol.XCIV (1963) presents evidence for the fact that Greek and Roman hulls were planked like shells, the frames being shaped and fitted to the form made by the planks ('Roman carvel construction'). Casson refers to Olof Hasslöf: Skeppsfynd, Arkivuppgifter och Levande Tradition, Ale; Historisk Tidskrift för Skåneland, 3/1962. (Transl. Wrecks,

Archives and Living Tradition' *M.M.* 49 (1963)) Hasslöf here launched the definitions shell, as opposed to skeleton, construction.

28. The composition of the bow-timber as indicated by the artist (apparently well-infomed about ship's-carpentry) resembles 19th century practice with heavy timbers bolted together.
29. See particularly Figs. 5 and 6.
30. There are reasons for regarding the large polychrome floor mosaics (of Hellenistic origins) as free compositions of panels of convenient size depicting fixed patterns or themes and prefabricated by shops but put together on the spot. See the famous Nile mosaic at Palestrina composed from obviously separate panels (although the visible joints are the result of partition in modern times to facilitate transport. Designs of individual panels remained in vogue over considerable periods.
31. Sjöquist 'Studi interno alla piazza del Collegio Romano' *Skrifter utgivna av Svenska Institutet i Rom,* XII Vol.IV refers to a late extension of the *cura annona* practice (free distribution of grain) but in charge now of the Roman ecclesiastical administration and still operating in the time of Gregory the Great.

CHAPTER III

Wooden shipbuilding and the existing fragments of cargo-vessels

(a) The principles of carpentry and the shipwright's art: timbers and tools.

To the shipwright of antiquity the making of a ship's hull, in particular of an oar-propelled, light displacement hull, was an extremely difficult task. Thus there is reason to preface our account of the hull-fragments here covered by a general review of the principles, methods and tools of carpentry and shipbuilding in antiquity as far as they are known to us – and our knowledge is in fact very limited. It is of equal importance for us to have some knowledge of the kinds of wood used by the Greeks and their neighbours, as well as by the Italic tribes and the Etruscans, what sorts were at their immediate disposal and what sorts could be acquired from abroad in the Mediterranean.

Homeric poetry, which combines the material and spiritual culture of the late Bronze Age with that of the so-called Dark Ages, provides us with some facts about the handicrafts, trades and everyday life of those centuries. The fifth book of the Odyssey[1] describes the building of a 'raft' by Odysseus to carry the hero from the island of Calypso; lines 243-255, which tell us what he did, are frequently cited: the cleaning of the twenty logs, which are trimmed by the use of a cord and fitted together by mortises. He uses only a double axe (adze) and a drill, the task requiring no more tools.

Of a more tricky character was the building of the bed which Odysseus narrates to Penelope, to confirm his identity, in Book 23, lines 188-200. The trunk of a living olive was cut, as it stood, hewn and shaped into a log for the bed. Vertical elements were fitted by using the drill, but these parts are not given in detail. Pegs, trenails not metal nails, were apparently used. The architects of the Minoan-Mycenaean palaces used timbers as supporting baulks, struts and pillars, and parallel to these we find humbler edifices made of sun-dried bricks and rough-hewn timber. Greek architecture proper, as it developed into the Doric style of public buildings in stone, was still basically wood-construction using heavy timbers. These wooden buildings were in turn sheathed in decorative terra cotta elements fitted by means of nails. Dinsmoor[2] concludes from the work of previous scholars that the Doric style executed in stone[3] derived from timber archtecture (the proto-Doric style), and this position is completely confirmed by Vitruvius[4]. Since Mediterranean forests produced only short timbers, joints were frequent and numerous, the method employed being a flat scarf fixed by trenails or pegs. Timbers, or hewn baulks, showing ends cut across the grain, had these surfaces covered by terracotta panels (mutules) fixed by nails or pegs (*guttae*)[5]. A building technique of this kind called for a developed carpentry, as well as for the skills of joiners and sculptors. We find the trimming of logs, and the use of a rough saw for the manufacturing of baulks and boards. We find, further, chisels for various purposes, probably also some kind of a plane, as well as various tools for carving and sculpting. The axe, as well as the double axe, is frequently mentioned. On the other hand the adze does not occur in literary references; but there is reason to assume its existence.

In the period of the Hellenistic monarchies the techniques of house-building, as well as of heavy carpentry, are obscure; but we are fortunate in possessing valuable material from the excavations at Delos and from those at Pompeii and Herculaneum[6] where the evidence takes the form of charred wooden elements including ceiling timbers, stairs, window-frames, door-frames and low wooden panels or partition-bulkheads. Products of the skill of the joiner are seldom recovered, but what is left presents evidence for a refined technique with a long tradition behind it. During the Empire we find[7], parallel to stone public buildings[8] a simple building tradition which includes basic carpentry. We are able to trace, independently of this, luxury work in furniture and decorative elements for well-to-do citizens, but only a limited amount of this has survived.

In this field underwater archaeology has assisted scholars by providing a limited number of test-pieces demonstrating practical tasks of a difficult nature but invariably well-solved, e.g., the fitting of longitudinal keel timbers involved complicated joints requiring a key-piece of wood fixed by a penetrating bronze bolt. European carpentry in the 18th century did not approach such heights. In general the tools of the Roman carpenter corresponded to the hand tools of the 18th century carpenter. Among machines drived by muscle-power in antiquity we find the turning lathe in use in late imperial times. According to Pliny the Elder delicate work such as lamination and intarsia work, which involved the cutting of thin sheets or films as well as special tools for the glueing process, was carried out in his time i.e. the reign of Vespasian.

From fragments of ships' hulls, as well as from certain representations, we have been able to deduce what tools were used by the ship's carpenters, the *'fabri navales'*. The tombstone of Longidienus (3rd century: now in Ravenna (Plate XV)) shows a man handling the carpenter's adze, with the edge arranged vertically. The joining of the planks, was effected by the mortise and tenon method required chisels of varying dimensions, as well as a drill. Among the miscellaneous objects recovered in the Nemi hulls is a wooden compass[12] which can be locked at a given angle, corresponding to the similar tool used by a modern carpenter. The hulls from Lake Nemi supplied us, in addition to basic structural details of ships of the early Empire, with a lavish set of information about joinery, nails and bolts of various sizes and about bronze fittings for furniture and interior work[13]. This material, exhibiting considerable skill and artistic taste, belongs to the eastern Hellenistic luxury tradition, but is the product of Italian workshops. As a mass deposit which can be exactly dated the Nemi finds are unique.

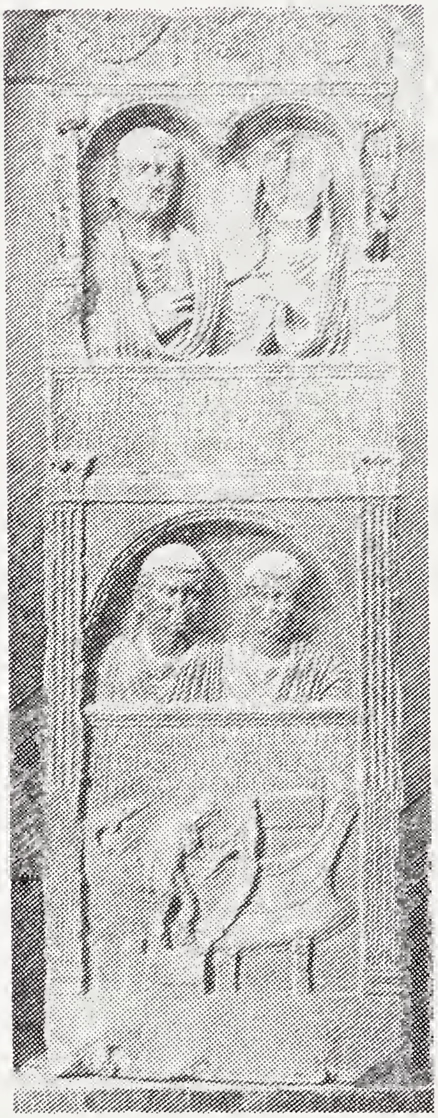


Plate XV. A tomb stele from Classis, the ancient naval base and port area of Ravenna, dated to the second or third cent. Museo Archeologico Nazionale, Ravenna.
The lower relief shows a hull planked up with a carpenter adding a frame.(P. Longidienus P.F. AD onus properat = P.L. is pushing on with his work.) Casson, "new light on ancient rigging and boatbuilding", sees this relief as the evidence for hulls being assembled like shells; frames, floors and longitudinal timbers being inserted afterwards.

The types of timber and their supply

An easy supply of timber has frequently been seen as the basic incentive to shipbuilding and maritime trade. Yet, whether forests were within easy reach or not, determined individuals and expanding city-states practised shipbuilding, and constructed merchant vessels and naval fleets. The traditional skill of the ship's-carpenter should be understood to be more important than an easy supply of timber.

In Homeric times Greece proper relied on its own forests and on domestic types of timber, i.e. on species found in the Balkan area supplemented by the forest reserves of S.E. Ionia. Trade in the finest timber took place in the Levant. Cedar was shipped from Syria to Egypt, and ebony, for luxury work, from Nubia to Egypt and Syria. According to sources of doubtful accuracy teak was brought overland from India to the capitals of the Persian empire. Conifers (cypress) were exported from Armenia to the ports of the Black Sea for shipment onwards to the eastern basin of the Mediterranean[14]. The Greek city-states of the 8th-6th centuries, still lacking the economic power of a silver currency, had to rely on domestic timber-supply. In classical times we find N. Greece and Macedon supplying the long timber required by shipbuilders, and pitch from the source is also mentioned[15]. Up to the time of the early Empire fine timber for ship-yards was exported from N. Greece and the mouth of the river Danube (Istros)[16].

The forests of mainland Greece; as well as those of the Apennine peninsular, were probably already used up by early Antiquity. The beginning of soil-erosion, for reasons which are well known, prevented the growth of the forests in these areas and resulted in the importation of timber from more distant places. The volume of such seaborne timber-trade cannot be estimated – it certainly changed from one period to another – unlike the volume of trade in commodities shipped in *amphorae* which carried the mark of the exports and of the potter and kiln as well. By comparison with modern times the consumption of timber in antiquity was probably heavy[17], indeed the colonial expansion of the Greek city-states may be seen as motivated by the demand for forests of full-grown timber. Such forestry reserves were to be found in the western basin of the Mediterranean and at the other extreme in the Black Sea area (Pontos Euxinos). Of the greatest importance were Thracian forests which were available to the Athenian empire in the classical period. Olynthus, on one of the peninsulars of Chalcidice, succeeded in achieving a short-lived hegemony as the result of a well-organised timber export-trade.

Woods common in Greece were: beech, oak, spruce, larch, pine, cypress as well as olive and acacia. Cedarwood was probably grown from early times. The palm, growing south of the central sea, was apparently not used by ship-builders. The kinds of wood listed were apparently used also by Italian builders, until the organised importation of high-grade, expensive, timbers became common in imperial times. Pausanias lists the kinds of wood employed in late antiquity and recommends and comments upon them. Neubürger[20] (acknowledging a debt to Blümner) lists the kinds of wood chosen for the various parts of a wooden hull: silver spruce for the keel, bowtimbers and floors (but oak or fir is acceptable), spruce for masts and spars, copper beech or black acacia for the planking. For the steering-oars olive or stone pine was recommended. Pliny the Elder mentions spruce as the proper timber for yards (*antennae*)[21]. This information is corroborated and completed by underwater archaeology and by tests on recovered wood carried out by European and United States forest laboratories in recent years.

(b) Principles of hull-construction

Carvel versus lapstrake (or clinker): an invalid terminology

For generations scholars avoided questions about the basic principles of the construction of ships' hulls in antiquity. It was regarded as sufficient to observe that the surface of the hull-side was smooth, the planks being put together edge-to-edge to form a watertight skin. The Nordic lapstrake technique, developed in the Iron Age, was regarded as alien and unknown to Mediterranean ship-builders and navigators. Carvel (i.e. smooth) and lapstrake techniques were looked on as contrary and completely alien to each other. Lapstrake was regarded as an Iron Age conception, typical of the craftsmen of the nordic medieval tradition. Carvel technique on the other hand was reborn on the Atlantic coast of Europe in medieval times, when new hull-types were introduced, to appear in the North Sea and the Baltic in the early 16th century.

The Nordic lapstrake hull is understood to have been set up by fitting plank to plank without a skeleton, possibly with the guidance of some moulds. Frames were shaped by the axe and properly trimmed to be inserted when the hull was complete. Yet in spite of advanced hull-design and structural flexibility the lapstrake principle was considered inferior to the carvel principle, though chronologically of a later date. The carvel hull was built on frames and end-timbers trimmed and fixed by temporary struts, the preliminary mock-up giving the final shape to the planked shell. When the frames had been set up the shipwright still had an opportunity to adjust any irregularities of shape which he noticed. This technique was considered the more advanced, with its roots in antiquity and receiving technical improvement during the medieval centuries within the Mediterranean area. Such views were still common during the nineteen-thirties and nineteen-forties until amended by two maritime experts independently of each other with the introduction of fresh material and the invention of a new terminology.

New Terminology: shell versus skeleton construction

Olof Hasslöf, the famous student of Sweden's western fishery etc., in numerous studies[22] stressed the fact that from the earliest times hulls were built according to principles which resulted in clean sides yet lacked all kinds of prefabricated structural elements set up in advance. Hasslöf further claimed that a hard and fast line between lapstrake and carvel was impossible, as both techniques might coexist in the same hull fabric: lapstrake being used in the hull below the water line, carvel above it. He noted certain Egyptian hulls from the 12th dynasty which showed planks fitted to each other by short wooden pegs (Scandinavian: *dymling*). Hasslöf launched the word 'shell-construction'. Hulls, on the other hand, which were set up on prefabricated elements and frames, were examples of 'skeleton construction'.

Hasslöf gave examples of Nordic hulls being built as late as the nineteen-thirties, following lapstrake technique from the keel to the waist with the freeboards finished in carvel style. Frames and floors were all inserted on completion of the hull. The shape of such hulls was not determined by frames, nor by a temporary mock-up, but was evolved step by step in the course of planking up[23].

Lionel Casson, the classical scholar, concentrates on Mediterranean shipping in antiquity. In his studies and popular books, by presenting perfect pieces of evidence and relying on material supplied by underwater archaeology already in the early nineteen-sixties[24], Casson demonstrates that the hulls of antiquity were fitted to each other by wooden pegs of rectangular section (*subscus*), held in position by nails driven through the plank. In spite of the discovery of floors and frames *in situ* in the wrecks surveyed, Casson convincing shows that such elements were trimmed and inserted after the planked-up shell had been completed. Casson relies in part on the *stelē* of Longidienus, which shows a shipwright trimming a frame for insertion in a hull completely planked-up; in part of shell fragments recovered from barges or river craft which were revealed when the Leonardo da Vinci airport was constructed near to the silted-up imperial ports at the mouth of the Tiber[25]. In a study of these fragments Casson demonstrates that the iron nails which fixed the frames to the planked shell had been driven through the flat tenons joining the planking, with the consequence that the planking belonged to a stage of building (before the insertion of the frames) which involved the painstaking mortise and tenon joining of plank to plank lengthwise, while the frames were inserted in the planked up shell and held fast by nails or trenails driven from outside[26]. These observations are further confirmed by a fragmentary plank raised from the wreck of a Roman carrier which had gone down at Cape Antheor (the 'Chretienne A'). This plank shows the scratched line for the frames which guided their insertion in the planked-up hull (cf. modern wooden yacht building), no notice being taken of the tenons already hidden along the seams.

At this point Casson's and Hasslöf's conclusions begin to converge. In his presentation of evidence collected from the Mediterranean area Casson reaches a conclusion very similar to that of Hasslöf in relation to Nordic lapstrake technique, i.e. that terminology relevant to W. European shipbuilding in modern times cannot apply to antiquity. Greco-Roman shipwrights observed the principles of shell-construction whether or not the resulting skin was similar to that of modern carvel construction. These principles, repeatedly documented by underwater finds, should be understood as a tradition of very long standing within the eastern Mediterranean. There is a complete absence of information regarding the use of guiding moulds, or a complete mock-up, which it is reasonable to expect in the case of the planking of oar-propelled warships, exhibiting as they do unusual lines which are difficult to translate into carpentry[28] are requiring difficult deformation of planks by steaming and twisting.

The arguments put forward by Casson are based on hull-remains and fragments recovered under water mostly on the Ligurian coast[29]. Material of equal importance is derived from the lost fund of examples of the ancient shipwright's art recovered from Lake Nemi. Fortunately the two hulls were 'taken off' by naval architects of the Italian navy, the plans being published in the excellent book by G. Uccelli, who handles these extraordinary remains with great skill. He duly observes the practise of joining planks by mortise and tenon and certain other peculiarities, all of which confirm Casson's basic conclusions.

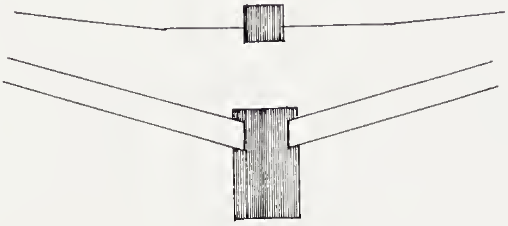
Not representations nor literature but under-water archaeology alone has led to real knowledge about ancient shipbuilding. There is then good reason to list and comment upon the wrecks and hull-fragments which have hitherto been published or referred to publicity. The list is not up-to-date.

(c) Roman or Hellenistic wrecks from which timber fragments have been recovered. (Plate XVI).

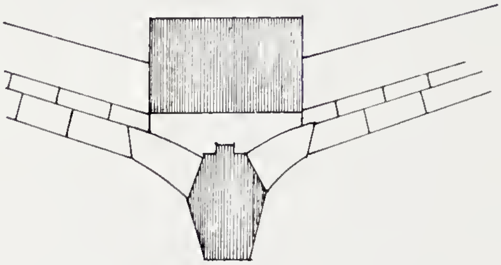
1. 'Galère de Caesar'[31]: a fragment of a bottom including the keel-timber, fragments of the keelson and of the planking. Dated though pottery to the 3rd or 4th century AD: found in the ancient port of Marseilles called the Lacydon during dredging in 1864. Now in the Musée Borély.
2. The County-Hall hull[32]: a fragment of a Roman cargo-carrier: a part of the bottom including the keel, 38 frames nailed to the planking, one light sheer-strake as well as considerable areas of the planking in which joints and scarfs are found, as well as planks ending in a wedge shape. Floors were not found. The hull was discovered when digging was in progress for the present County Hall of London in 1910. Dated by coins to the early 4th century AD.
3. The Mahdia wreck[33]: a fragment of the keel with adjoining planks of about 9m in length belonging to a cargo-carrier lost off Mahdia on the coast of Tunisia. This famous wreck of a ship carrying important objects of art and archtectural elements was relieved of its cargo in 1907-1913, but at that time the hull was not examined. The fragment of hull was raised in 1945-55. The loss is dated, by an analysis of the sculptures carried, to Sulla's looting of Greece in 86 BC.
4. The Sulcis wreck[34]: important remains of a Roman carrier of an estimated length of about 23 metres, located and raised during the dredging of the Port of St Antioco -- the Sulcis of antiquity – in Sardinia. Nothing was properly studied or conserved. There is no literature about it with the exception of some notes in the local newspaper.
5. The Nemi hull[35]: two structurally well-preserved flat-bottomed hulls recovered by partially draining the lake Nemi, frequently called the 'galleys of Caligula'. These hulls were built as pontoons to carry the emperor's luxury gardens; they exhibit a low freeboard but an extraordinarily strong deck-construction. The planking is sheathed in tarred canvas (made of flax) which is covered by lead-plating in the style of the best sea-going ships. The pontoons were fitted with symbolic bow- and stern-decorations as well as with a complete set of steering-oars on outriggers.
6. Barges and boats in the Portus area[36] These are flat-bottomed barges or river-craft excavated during airport construction within the Portus area. One hull of 11.3 m length was reported found in the nineteen-twenties in the northern corner of the octagonal basin built by Trajan. In 1959-60 about seven boats or small barges were uncovered in the area equivalent to the anchorage sheltered by Claudius' breakwaters levelled for the runways of the Aeroporto Leonardo da Cinci.
7. The wreck of Grand Congloué[39]. Only a very limited number of hull fragments, yet extremely important ones, were recovered from this site. They belonged to the keel and the adjoining planking and exhibit the mortise-and-tenon method of joining planks (subscus). The cargo which covered the bottom was composed of amphorae and ceramics for export, through which the wreck could be dated to the years 228-150AD. The site was close to the island of Grand Congloué about 12 kms to the south of Marseilles at a depth of 32-42 metres.
8. The wreck called 'Le Titan' (also Ile de Levant)[38]. Of this wreck the keel with the keelson and the adjoining planks were freed from sand and documented. The reconstruction drawings (by Ch. Lagrand) show a most complicated fabric with a double skin of planking on the frames starting from the keel timber, all fastened by nails. The keel and keelson are bolted together by trenails driven through the floors. Found at the Ile du Levant.
9. The Cape Dramont wreck[39]: fragments of the keel, floors and planking. A reconstruction by J-M Rouguette and Ch.Lagrand) shows a fabric with a weak keel but an extraordinary keelson sunk in the floors. The planking is doubled, partly fixed by trenails partly by nails to the floors.
10. The Monaco wreck[40]. The fragments recovered show solutions astonishingly modern, as reconstructed by J-C Roux. The keel, of rectangular section, is robust and furnished with a deep rabbet line.
    Long, heavily dimensioned floors are fixed by copper bolts through keel and keelson. The outer planking is single. An inner planking lining the cargo-hold is carried high up and was apparently caulked. The longitudinal robust keel timbers were joined by means of scarfs of extraordinarily clever design which exhibit admirable precision and a high degree of skill in carpentry.

Plate XVI Midsections of 6 representative wrecks of cargo carriers from Hellenistic - Roman Centuries

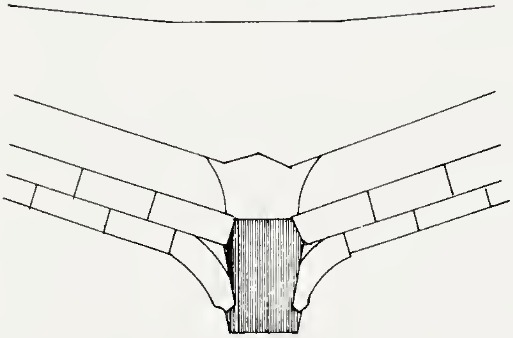
Sketched by: Henry Forssell



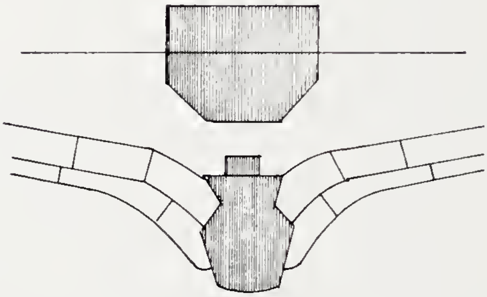
The S.C. "Galere de Cesar", a hull fragment recovered in 1867 during dredging-operations in the old port of Marseilles: the Lacydon, dated to the 3rd or 2nd century B.C. Musee Borely.



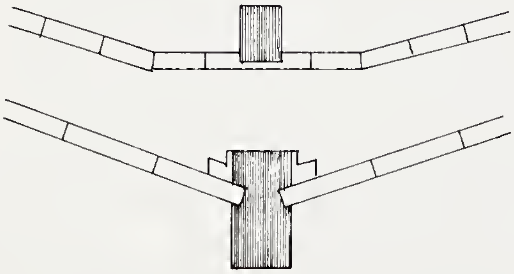
The wreck called "Dramont". Fragments of keel, keelson, floors and planking. In contrast to the over dimensioned keelson, the keel proper is weak and lacking a rabbet-line. With exeption of the first plank planking is doubled.



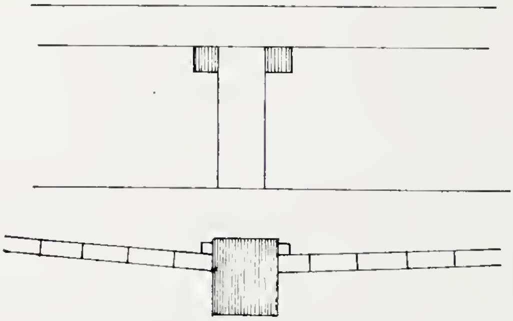
The wreck called "Grand Congloué" acc. to the island S. of Marseilles, investigated in 1952-57 by F. Benoit. The wreck is dated to between 228 and 150 BC. The keel is weak and a keelson is lacking but floors are very robust and the planking is double all over.



The wreck called alternative "Le Titan" or " Ile de Levant", surveyed and documented by Ch. Lagrand. The keel and the keelson are bolted together by heavy trunnions piercing the floors. Planking is double all over; apparently the innerplanking is watertight.



The wreck called Monaco, a fragment documented by J-C Roux. With a rectangular high keel and a harmonizing keelson combined with strong floors all bolted together by bronze-bolts, this system comes very close to 19th century conceptions



The Nemihulls are flat bottomed pontoon-shaped hulls with battens acting as floors embracing the whole bottom. Planking is single and a sealing innerplanking is missing.

11. The Chrétienne 'A' wreck[41], also called the wreck of Antheor. Fragments of planking with five frames and the corresponding inner planking have been recovered, while considerable fragments of the keelson, inner planking etc., were left undocumented and later disappeared. Fragments of the keel proper were not observed. Copper nails were used in the fastening of the planking. The loss is dated by objects from the cargo to the first century BC. Found close to the Cape Antheor beacon.
12. The Torre Sgaratta wreck[42]; insignificant remains of planking with frames from a large-sized carrier hauling roughly hewn marble sarcophagi from an eastern to an Italian port. The cargo and the hull remains were investigated by Peter Throckmorton. Some wooden elements were conserved by the naval yard of Taranto. Found off the village of Torre Sgaratta on the sandy coast to the east of Taranto.
13. The Pantano Longarini wreck[43]: the stern part of a large-sized carrier found silted up in a land-locked marshy pocket on the south coast of Sicily. The bows and the keel members are lacking. This robust and coarsely built hull, entirely lacking in finish, shows floors continuing upwards as hewn frames (in the style of 16th-18th century ship's-carpentry), longitudinal stringers inside as a means of fitting heavy deck beams, and considerable areas of planking in a preserved transom stern. The scantlings of this hull differ from all the hulls previously mentioned in being much heavier. This wreck is dated to about 500 BC. The excavation and the measurements were carried out jointly by Peter Throckmorton and Gerhard Kapitän.

Comments on the List of Wrecks

This list is far from complete for various reasons. The Roman wreck at Spargi[44] was investigated by the Italian Dottore Gianni Roghi, but no publication of the findings has been made. Numerous Roman wrecks along the French Riviera have been identified and looted by underwater robbers outside the control of the archaeological authorities, the capacity of institutions and museums in this respect being limited. The situation in Italy is almost similar, thus the number of underwater sites identified but lost to scholars has been increased. The underwater teams sponsored by Pennsylvania University and often directed by George Bass[45] have achieved a special position in this field. These groups have been carrying out work of the greatest importance, pioneering new technical tools and advanced equipment, mostly in the eastern basin of the Mediterranean. Reports have been available in learned and popular magazines alike, as well as in the regular reports of the American Institute of Nautical Archaeology. Active in the Sicilian area is the German Gerhard Kapitän, resident at Syracuse, frequently working for the Italian archaeological authorities. Another well-known free-lance underwater archaeologist is Peter Throckmorton active in the eastern as well as in the central Mediterranean[46].

There is reason to expect that with an improved underwater technique and careful treatment of finds an increased volume of timbers, floors and fragments of planking will be raised, measured and documented. The number of important wrecks, promising structural fragments to students of ancient carpentry, but in fact looted and vandalised, is unfortunately growing[47]. An archaeological site is irrevocably damaged, and cannot be restored, once certain strata are penetrated and broken. Underwater sites are constantly affected by local, sudden currents, by wave action on the surface etc., and these vicissitudes all add to the difficulties which excavators meet. The important Nemi hulls were destroyed by flames[48], the Pantano Longarini wreck was broken up by local peasants to be sold as timber, considerable parts disappearing before the arrival of archaeologists. Yet there is reason to trust that the appearance of new wrecks of carriers of late antiquity may compensate for the losses mentioned. Yet there cannot be an unlimited supply of new sites at workable depths, and there are accordingly strong reasons for fast action by governmental bodies to ensure the security of ancient shipwrecks.

Notes on the hull-remains recovered from underwater sites

What information is to be derived from fragments of ancient hulls? Since there is a considerable number of known sites we should theoretically be in a position to handle and study a vast number of fragments, so long as this material is recovered, measured, drawn or photographed etc., As a consequence of the inferior status of maritime history and archaeology, and the lack of any international forum for this new branch of the antiquarian disciplines, most of the wreck-sites listed are merely vague names or symbols. On the other hand the secondary objects of art and architecture, semi-fabricated elements and especially the *amphorae*, are keenly studied by the respective specialists[49], the remains or fragments of ship's-carpentry being generally neglected and thus soon spoilt. Works of art being the target of looters or pirate divers out for money, wooden fragments are turned over and left exposed to the ever active teredos. Apparently much information could have been cleaned from the famous 'art-wrecks' of Antikythera[50] or Mahdia[51], especially from the higher strata of the *tumuli* raised by currents around a hull which has settled on the sea-floor, if the excavators had shown the slightest interest in nautical matters.

Of the wrecks listed none has been such as to supply more than some minor details, but analogous fragments found in a number of hulls have made a comparative study possible. In these cases the dating of the cargoes carried enabled a chronology to be constructed. Coins, frequently found in 'dry' wrecks covered by soil, add to the precision of such chronologies. The study of comparative material gleaned from a number of wrecks and carried out by specialists in ship's-carpentry would certainly add to our knowledge. Of the greatest value to the community of scholars would be a 'corpus' dealing with ship's-carpentry and covering the whole body of information derived from ancient wrecks. On this suggestion we may cite Honor Frost: 'the evidence might not come from a single wreck, but would be built up on a comparative basis. It is not easy; but the method should be tried'.

The Lessons of the Nemi hulls: a technical analysis (Plate XVII)

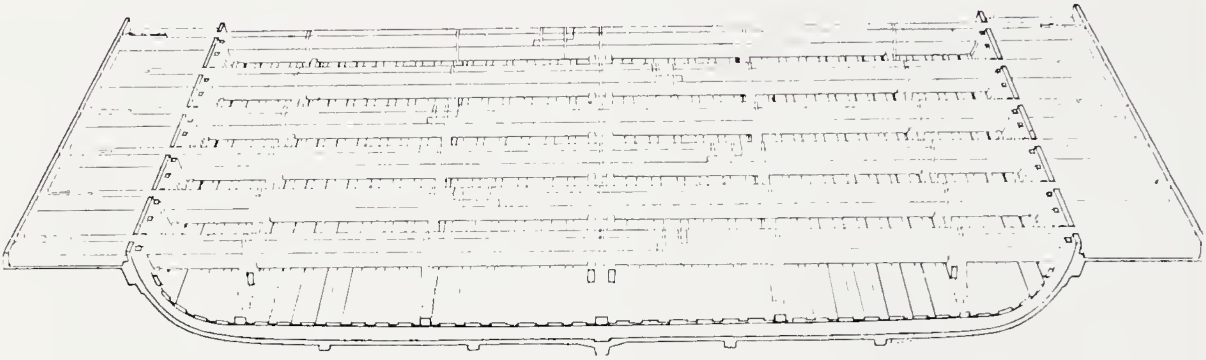


Plate XVII A section of the Nemi hulls showing double planking to frames and floors combined, one central keel and 2 + 2 lateral weak side keels. Structural strength is supplied by the extra ordinary bolted up deck beams protruding over the ships sides and resting on a weak shelf. These beams are hinged to a total of five lateral keelsons. From Uccelli, Le Nave.

The hulls of the Lake Nemi vessels, which cannot be called ships, are in spite of their sad destruction in 1944 to be regarded as the most important remains of the shipbuilding industry of late antiquity. To the fascist régime of Mussolini's Italy well-known hulls could be used as propaganda weapons in the Mare-Nostrum policy and the claim to the territories of imperial Rome. As a result considerable funds were budgeted for excavation, for conservation and documentation. The publication of the monograph on the two hulls was however delayed, so that the book appeared only in the second World War: 'Le Navi di Nemi' by Guido Uccelli was originally published in 1940, and a second edition was brought out in 1950 sponsored by the Instituto Nazionale d'Archaeologia e Storia dell'Arte. The work is made up of a number of separate studies backed by Mussolini and the régime, which includes the ambitious task of 'taking off' the lines of the wrecks and reconstructing them, in theory handed to the Royal Italian Navy and actually carried out by the Naval yards and their staff of naval architects. The drafting work was probably completed during the first years of the second World War. The scope of the book encompasses much more than the two wrecks. It deals with interiors and joinery-work, objects of art, technical and hydraulic details. Fortunately the author stresses the ship's-carpentry displayed in the enormous assembly of timber, as well as nautical equipment recovered. In a comparative study the author attempts to analyse the hulls against the background of nautical archaeology up to 1950 ('Ships of antiquity within the Mediterranean'), a year which marks the appearance of the scuba-diver equipped with inexpensive suits and gear made possible by the extraordinarily fast war-time development of diving. Uccelli's important study is barely known among N. European scholars because of the language. The volume, as far as the ship's-carpentry documented in it is concerned, may well be regarded as an encyclopedia of shipbuilding, limited however to the Mediterranean and the ancient world.

Technical Details of the Nemi Hulls

The excavation of the mammoth hulls, reclaimed by draining lake Nemi and environs and cleared by the spade in the orthodox way, was generally regarded as having been an unprofitable operation since no first-rate works of art were in fact recovered. Visually attractive objects were published in daily papers and in journals, but very few people showed any interest in the remains of the deck, the planking and the very complicated timber fabric which could be understood only by a few. Yet the fabric and the puzzle of fitting into it various stray fragments led to first rate knowledge of ship's-carpentry in the Roman empire.

Originally covered by a light luxury deck, made up of Roman brick, marble sheathing or mosaic slabs possibly supported by low terracotta pillars similar to those found in the double flooring of the hypocaust heating structures[53] we find a set of heavy horizontal deck-beams supported by vertical wooden stanchions stepped on the keelson or on a set of stringers (intercoastals in modern terminology) parallel to the keelson. The construction is logical, strictly functional and of considerable strength. The planking is carried out with mortise-and-tenon joints in the best fashion with the wooden elements secured by copper nails. The planks are generally parallel, but there are some wedge-shaped ones naturally, such thin elements being fitted each to its neighbour by nails. The next plank is in turn fitted to the next with mortise-and-tenon joints. Hewn frames are found throughout at a very short distance from each other. The joints visible in the frames exhibit three different methods, all functional and nicely executed (Plate XVIII). Planks are attached to the frames with copper nails, the heads counter sunk in pre-bored holes and all covered by wooden plugs. The nails, emerging on the inside, are bent to 90° and the ends bent again to 90° and driven back into the frames ('clinched')[54] (Plate XIX). The planking is covered with linen canvas which is treated with tar or pitch, and sheathed with lead fitted by means of small copper nails. The centre keel and all protruding timbers were covered with lead, but this sheathing was not brought upwards above the heavy wale supporting the protruding deck-beams. In the narrow space beneath these deck-beams the inner planking is carried out in a way resembling the modern method of cargo-battens, i.e. every other plank is broad and every other narrow so that there are gaps between them, the purpose of the inner planking here being insulation only. At least one well is found, of square section, for a plunger- or kedge-pump.

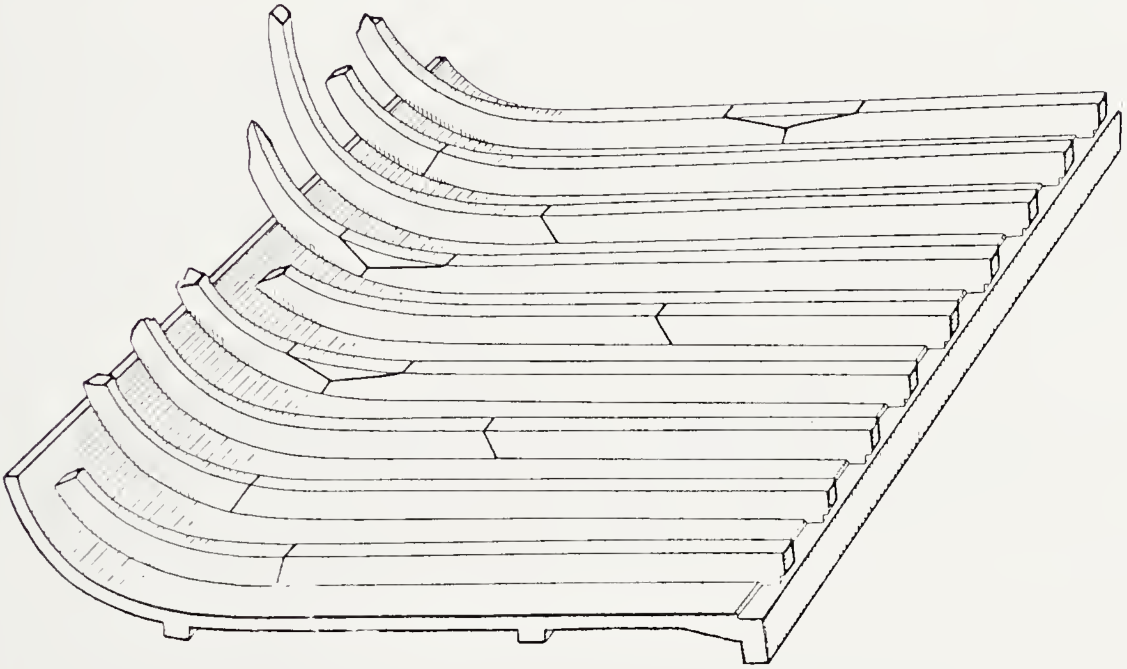


Plate XVIII Various methods for joining frames employed in the Nemi-hulls. The triangular joint re-appeared in modern times. One-piece timbers always crossed the keel-timber. There are reasons for this order to have been maintained in general. From Uccelli, Le Nave.

Only a few fragments remain of the bow-timbers, since these elements were possibly damaged and raised by the salvage men and treasure-hunters of the Renaissance working for various princely employers[55]. Some bronze fittings, U-shaped in section, seem to have a concave profile and may have belonged to the bow-timber above the

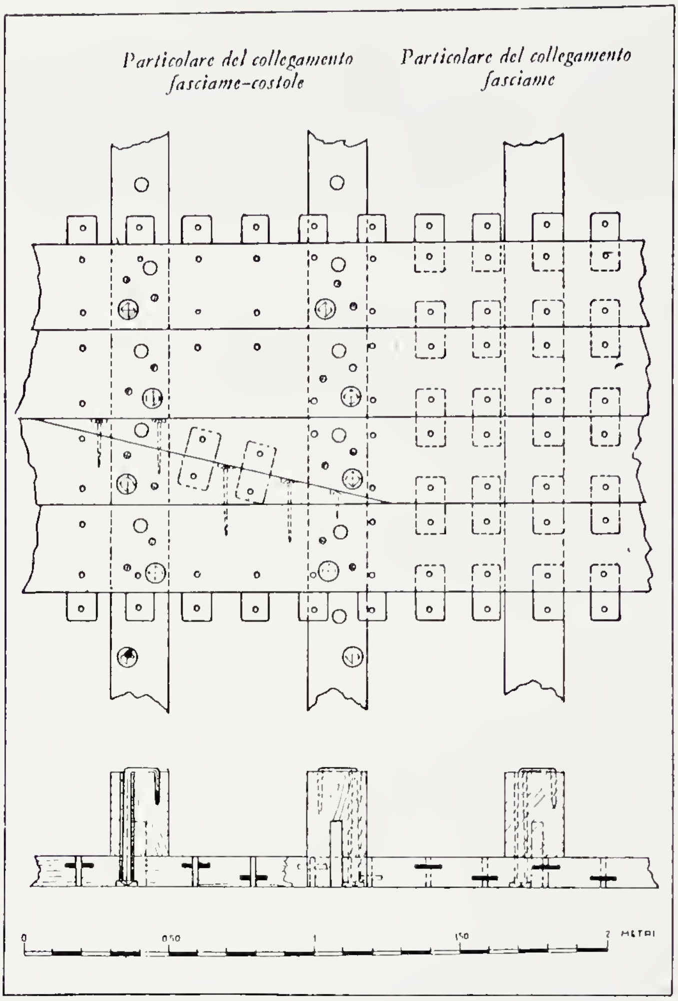

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Plate XIX A sketch showing the method of fitting planks to the frames employed in the Nemi-hulls. To the left the pattern for driving nails into the frames, respectively for joining planks. – to the right the method for joining planks to planks by flat wooden "Tongues" – "Subscus" or "Cuneus" – secured by nails. In a first-class hull only copper-nails and bolts were allowed. Diagram from Uccelli. Le Nave.

ram-like beak. The stern may have resembled the *aphlaston* of the oared ship, but the evidence is weak. The protruding side-deck corresponding to the *parexeiresia* (ital. *apostis*) of the oar-propelled warship, are planked on the underside as well. The same is true of the protruding platforms in the stern which take the heavy steering oars. The breadth of the deck, including the side-extensions, provides a surface of immense dimensions quite impossible for a seagoing ship.

At this point we approach the peculiar character of the Nemi hulls. When they designed and built the immense pontoons to serve in the capacity of floating gardens, the men responsible for the task relied on the naval carpentry of the 1st century AD seen as the hallmark of the imperial navy. In spite of the enourmous breadth, of the immense wetted surface and the huge displacement, the designer or builder kept strictly to all the principles applying to the swift oar-propelled vessel. The sections of the keel and keelson are appropriate to a hull of only one third the actual breadth. The planked shell of the hull is a fabric of high quality but too weak for the displacement actually involved. If they are to correspond with dimensions set by the experience of the 17th and 18th centuries, the sections of the hewn frames ought to be increased four-to six-fold. For the purpose of stiffening the extending, flat, hulls we find that the deck-beams, make up of two heavy planks joined together, are supported by stanchions resting on the keelson and four (two on each side) paralled stringers (intercoastals). Nevertheless the structure of frames and stringers is too weak for the actual immense displacement, apparently too weak also to carry their heavy burden are the stringers which carry the deck-beams. The heavy rubbing-strakes on the outside do however compensate for this weakness.

In the details observed and noted here we may trace a tradition of long standing[56] governing the dimensions of structural elements. When the overall dimensions were increased to the limit a corresponding increase in the sections of critical elements was not considered necessary. It appears that the task of building the Nemi hulls was quite out of the ordinary for the naval yards involved. As evidence for the opinion expressed (which refers equally to the construction of warships and merchantmen) we may take the underwater sheathing of tarred canvas and lead designed as a precaution against the teredos, since no such danger to exposed hulls could possibly be present in the crater-lake in the Alban Hills. Equally appropriate to a seagoing ship but inappropriate to a stationary and permanently moored pontoon are such features as bow decorations and steering-oars.

There is reason to believe that the hulls, ordered for the imperial-court, were built by carpenters, workers and slaves from a naval yard, possibly Misenum. It may further be assumed that the standards of such establishments have been maintained throughout[57]. At a later stage architects, garden-designers and decorators of all descriptions, were called in to carry out the intentions or the whims of their imperial employer regardless of expense We may then see that the basic principles of the structure, as opposed to the scantlings as measured, typify first-class shipbuilding of late antiquity.

Ships of bigger overall dimensions were probably not built during the next centuries. The obelisk-carriers of ancient literature were undoubtedly seagoing sail-propelled carriers of round shape, but of immense displacement, not comparable with the pontoon-like Nemi hulls of extreme dimensions (length overall 71.30 metres/73 metres, breadth 19.30/23.50 metres, loaded draught approximately only 3 m.)

Luigi Tursini, in a study[58], attached to the book above-mentioned, concentrates on hull-shape in a comparative survey and expresses the opinion that hulls of similar shape to the Nemi hulls would be capable of movement under sail or oar. Such an opinion must be considered as arising from a tendency to regard the flat-bottomed pontoons as real seagoing ships, an extreme opinion actually put forward frequently in the daily press during the years of excavation (1928-30). The circulation of such ideas (which lacked any foundation) caused much confusion among people who lacked nautical commonsense and a basic understanding of ships and ship building, and looked at the huge pontoons and their general shape and proportions as documents illustrating the maritime tradition, naval as well as mercantile, of the happy heyday of the Roman world. – Yet these people did not understand the nature of the enormous displacement figures.

The Importance of the Nemi Hulls

Having considered the Nemi hulls from the point of view of ship's carpentry we may reasonably regard the document which covers this point of view – Uccelli's book – as an encyclopedia of ancient shipbuilding, the methods employed and the materials used. Thus in future sections of this study we shall compare conclusions from underwater sites with facts put forward by Uccelli. A limited number of scholars and writers have given due weight to the immensely important material recovered in and around the two wrecks, but its significance is neglected by the great majority, apparently for the sole reason that Uccelli's book is in the Italian language.

NOTES TO CHAPTER III

1. See Homer: Odyssey Lanol. E.V.
2. William B. Dinsmoor *The Architecture of Ancient Greece* Ch.2 : the origin of Greek architecture.
3. Dinsmoor, *op.cit.* p.57-8.
4. Vitruvius *On architecture I* Book IV 1-3.
5. Dinsmoor *op.cit.* Fig. 20.
6. *Exploration Archéologique de Delos* École francaise d'Athènes. This imposing series was published 1909-39, 1956-50.
7. August Mau *Pompeii in Leben und Kunst,* W. Engelmann *Neuer Führer durch Pompeii.* In Herculaneum wooden baulks are preserved while wooden floors, doors, panels etc., were blackened by the heat, but preserved in ash. Pompeii was covered with ash and lava mixed with ram-water, yet fires raged in the town.
8. Meiggs *op.cit.* The Houses p.237-42.
9. Benoit *op. cit.* Figs 79 and 146.
10. Gummerus *Darstellungen aus dem Handwork auf Römischen Grab- und Votivsteine in Italien* Jahrbuch des Kaiserlichen Deutschen Archäologishen Instituts Vol XXVIII. On a *stelé* from the early 1st century BC we find a set of carpenters' tools. *Lexicon der alten Welt* 'Holz' A Bearbeitung (W. Krenckel) p.1317 mentions the plane, the auger, the saw etc.,
11. *Lexicon d.a.W., ibid* p.1214 gives a reference to Pliny's mention of the lamination of wood.
12. Uccelli, *op.cit.,* Fig. 207.
13. Uccelli, *op.cit.,* p. 151-159, 163-166.
14. *Lexikon d.a.W.* 'Holz' C: Handel (H. Brechvert) p.1315.
15. *Ibid.*
16. Vitruvius *op.cit.* 1, 2, 9, 10 gives the most common kinds of wood useful as well as unsuitable.
17. *Lexikon d.a.W.* 'Holz': Verwendung (C. Krause).
18. *ibid.* Holz C Handel.
19. Pausanias *Description of Greece* 8, 11, 2.
20. Albert Neubürger *Die Technik des Altertums:* Griechische und Römische Schiffe, p.490-492.
21. *ibid.* reference to Pliny XVI 39.
22. Olof Hasslöf 'Carvel construction technique: Nature and Origin' *Folkliv* 1957-8. *Skeppfynd, Arkivuppgifter och levande Tradition: Arkeologiska Båtfynd och levande Tradition* Västerbotten 1958.
23. Hasslöf Skeppsfynd etc., Series of pictures 4-5, 6-7.
24. Casson: 'Ancient shipbuilding: New light on an old source': *TAPA* Vol. xciv (1963).
25. Casson: 'Harbour and river boats of ancient Rome' *JRS* lv (1965) Plate 1 2. *The Illustrated London News* 5 November 1960.
26. Casson: 'New light on Ancient Rigging and Boatbuilding' *The American Neptune* xxiv 2 (1964).
27. *ibid.* 88.
28. In the hull of the Greek oared war ship as pictured on attic vases there are shapes which would be very difficult to carry out in reality. Planks would have to be bent and twisted and thus steamed. Such curvatures make it necessary for plates to be cut to the required shape from very broad timbers with a considerable spill.
29. Casson here refers to Benoit.
30. Uccelli *op.cit.* Tavole I-X.
31. Benoit *op.cit.* p. 145 Fig. 78.
32. W.Riley and L. Gomme *Ship of the Roman period discovered on the site of the New County Hall* London 1912
33. Alfred Merlin, 'Les fouilles sous-marines de Mahdia' *La Revue Tunisienne.* Lingots et ancres trouvés en mer de Mahdia. J. Carcopino *Sylla et les fouilles sous-marines de Mahdia.* Werner Fuchs *Der Schiff fund von Mahdia in Musée Alaoui zu Tunis* (concerned purely with aspects of art history). See bibliography for detail.
34. Uccelli *op.cit.* p.250-1, G.C. Speciale 'Le Nave di Sulcis' *L'Ingegnere* (1939).
35. Uccelli *op.cit.* See further articles by Ugo Antonielli, Felice Barnabei, Corrado Ricci, Vittorio Malfatti and G.C. Speciale.
36. See note 25.
37. The wreck and the objects found in it were published by Benoit in a study of great merit which contained views on contemporary methods of research (1952-7). The task was originally assigned to Yves Cousteau who received considerable funds and official backing. Benoit had only the resources and backing of the Museum of Borély. Benoit: 'Une nouvelle Étape de l'archéologie: les recherches sous-marines' *L'Erma di Breitscheider* I (1961).

38. Benoit *op.cit.* Plate xxvii. This find is mentioned in the introduction to the publication of the wreck of the Grand-Congloue. The fragments show nails driven in a complicated pattern, as well as tenons secured by nails.
39. Benoit, *op.cit.* Pl. xxviii shows a section of the keel and keelson with double planking as well as the keelson with chiselled notches to take the ends of the frames.
40. Bennoit *op.cit.* p.145 Fig 79.
41. Frost *op.cit.* Pl.xx: a colour picture of planking and frames. See the appendix p.261-268.
42. A stencilled report by Peter Throckmorton.
43. P. Throckmorton and G. Kapitän 'An ancient shipwreck at Pantano Longarini' *Archaeology* 21 3 (June 1968).
44. Gianni Roghi 'Note technice sul relevamente e lo scavo della nave Romana di Spargi'.
45. George F. Bass 'Cape Gelidonya: a bronze age shipwreck' *American Philosophical Society*. See also 'Archaeology under water'.
46. Peter Throckmorton was in charge of fieldwork in many sites and was the author of many articles. Originally a journalist and photographer he became a free-lance archaeologist.
47. The situation of archaeologist sites under the surface of the sea from the 1960's onwards gives cause for anxiety as the number of uncontrolled divers increases and adds to the threat to important underwater sites. The prices paid for simple Roman antiquities lead professional divers to loot wrecks in a wholesale manner. As a result the French government has organised a corps of coastguard divers.
48. Uccelli *op.cit.* 'La distribuzione delle Navi' p. 303-323.
49. Objects of art observed in the wrecks at Antikythera and Mahdia stimulated rapid salvage work. Hopes of the recovery of important objects of art caused the Fascist government to allocate significant funds to the Nemi project. The discovery of large series of *amphorae* of a similar kind enabled students to establish the place of manufacture as well as to put together the evidence necessary for the establishment of ancient trade-routes. Large cargoes of export-pottery were useful in the same way. Frequent finds of semi-fabricated architectural elements, sarcophagi etc., emphasise the existence of locally-differentiated production within the Empire.
50. Salvage work started in 1900 directed by J.N. Svoronos. See: 'The Antikythera Shipwreck reconsidered' *TAPA* NS 55 (1967).
51. Work started in 1907.
52. Uccelli *op.cit.* Leggende e realtá p.5-33. A bibliography is included.
53. Uccelli *op.cit.* Fig. 165.
54. Uccelli *op.cit.* p. 151-155
55. In 1446 Leone Battista Alberti arranged for the recovery of a lead tube the factory marks of which were interpreted wrongly. In 1535 Francesco de Marchi had special equipment built and transported to the lake, but without result. In 1827 Annesi Fusconi designed a diving bell operated from a raft.
56. Typical of all the wrecks here presented is weakness resulting from the inadequate dimensions of supporting and binding structural members, i.e. keel and keelson, bow and stern timbers, frames and floors, stringers, wales (strakes) etc. The ship's-carpenter, working by trial and error, apparently did not calculate nor realise the rapid increase in displacement following increases in the main hull-dimensions (a fact known to naval designers of the 18th century). Thus we find shells of planking and frames in ships carrying immense cargoes of marble, granite etc., of fragile and astonishingly weak dimensions.
57. Ratings from the naval establishment of Misenum were regularly ordered to the imperial court to handle various tasks of public entertainment: *classiarii* handled the sun-awnings (*vela*) of public theatres and amphitheatres. Meiggs *op.cit.* p.305 mentions naval personnel permanently stationed in the Portus area. There are strong reasons to believe that the two mammoth hulls up in the mountain lake were executed by the imperial yards down in the bay of Naples.
58. L. Tursini 'Note di architettura navale Romana'. An article attached to Uccelli's study, p.369-393.

CHAPTER III (continued)

(d) An Analysis of Structural Timber-elements: How are the remains of hull-structures to be analysed?

The British scholar Honor Frost stresses the importance of a *comparative* method in the survey of fragments from wrecks of antiquity. With sufficient material at our disposal we should be able to construct chronological series of structural details and methods, based on the presence or absence of certain structural elements. Frost mentions the keelson as typical of late antiquity, seeing that it was an innovation from about the first century AD. In the Hellenistic period wrecks which can be properly dated show only short floors, probably bolted to frames only, seldom to the keel. Observations of this kind, resulting in similar conclusions, should be the task of diving scholars/investigators.

By means of such a comparative method applied to an increased number of wrecks over the whole Mediterranean area geographical typologies also could be constructed. The basis for these typologies would be the ability, which now seems possible, of identifying the origin of the cargoes in each case, both the place of manufacture as well as the date being roughly estimated. The carrier's home port is naturally not identical with the port of loading for the cargo, yet there may be a chance of finding out the general area to which the ship belongs by considering the composition of the cargo and the known business connections in the area in view, as well as the general conditions prevailing in long-distance trade. Reliance may further be placed on objects of a more special kind, e.g. coins, personal belongings, cult-objects etc. Yet the identification of an exact home port or a certain coastal district for a certain vessel may not be of much importance in as much as local patterns, which existed before Roman unification, apparently became fused into a common technology. The London County-Hall remains and the simple fact that we find a typical Roman carrier depicted roughly on an object recovered from the German river Weser during dredging corroborates this view. Thus a survey of structural elements found in wrecks and recorded and documented would rank items by their frequency; but such a list would lack technical significance of the kind provided by an account of structural elements presented and explained in the logical order of wooden hull-construction (i.e. the order in which the work was carried out).

Structural complexes in the Nemi hulls, as well as comparative observations in contemporary ship-representations, are discussed under various headings. This section is concluded by a brief summary.

The principal hull-elements as observed in underwater sites

(i) Planking.

Fragments of planking are frequently found, irrespective of the condition of the hull in general, as the skin covered by cargo may be found unaffected by the teredos. Planking was found in the following sites/wrecks: 'Galère de Caesar', County-Hall, Sulcis, Grand-Congloue, Titan, Cap Drammont, Chretienne A, Torre Sgaratta; Pantano Longarini is not yet accounted for. The most important information is however to be derived from the Nemi hulls.

In the remains above listed the planking was built up according to the method prescribed using flat wooden tenons (*subscus*) fitting into mortises. The planks are planed with great care resulting in tight seams with no oakum used[58]. In cases where the carpentry is absolutely first-class (e.g. at Nemi), there are two rows of wooden tenons, each placed alternately closer to the outside and to the inside of the planks jointed (longitudinally). The planks are joined by nails driven through in successive order, using bronze nails forged individually to proper lengths (end-to-end) joints in planks are actually found in underwater sites, but have apparently not been studied or conserved, since the method of attaching one plank to another (end-on) has not been discussed or displayed in drawings. However the method of such joints is well shown in the Nemi hulls: the ends of the planks to be joined are planed (in depth) into a wedge-shape and the two wedge-shaped ends are laid together, the upper being nailed to the underlying plank. In the case of very thick planks this method is safe, since there are (also) mortises and tenons in the seams. It differs entirely from the Nordic early medieval technique (in lapstrake construction) in which the broad narrow planks are joined the other way (i.e. the wedge shape is made not by reducing the depth but by reducing the breadth of the timber towards the end of the plank; a clamp is added on the inside, ensuring tightness).

The carvel technique of the late medieval period did not adopt the Greco-Roman method, but rather the Nordic. All the joints however were placed where they were backed by the heavy, hewn, frames, which of course had been set up and finished before the planking started. (This new standard of ship's-carpentry differed from the Greco-Roman in as much as it involved an extraordinary increase in scantling and weights required in contrast to the light-weight carpentry of antiquity.)

From the details thus described we reach the picture of a self-sufficient, complete, watertight shell built up from the keel and the bow-timbers on temporary supports. There is nothing to show that prefabricated moulds were employed to indicate the curvature, built up on the keel and its extensions fore and aft. We have reason to think that the stern tradition of ship's-carpentry governing the trade in ancient times required that the shell should be put together and given its proper shape simply by relying on the eye and by experience without the help of moulds. At the same time the question must be asked whether light moulds were set up to indicate the intended breadth, the required freeboard amidships etc, since the customer must have expressed some requirements of carrying capacity, cargo areas, maximum dimensions overall etc., etc. Also, from a practical point of view, some moulds would have been useful in keeping the built-up hull in shape before the stiffening elements were inserted, i.e. floors, frames and longitudinal stringers.

Answers to the question how the naval architects of antiquity shaped their hulls, translated, in fact, the visual image into a real ship, are not easy to find. Yet we can certainly say that a skeleton of frames and battens, which would have permitted a certain amount of adjustment, was not known at this period. Most probably the hull-shape was evolved simply by fitting one plank to another while the basic lines were those approved by an immemorial tradition, improvement being inhibited by a stern conservatism. It is very clear that old, approved, methods were retained, in the details of carpentry and in the lines of the hull, in as much as the scantlings of the hulls studied makes a comparative analysis possible; and when, in the trend towards increasingly big carriers in the heyday of the Empire, the overall dimensions of cargo-ships increased, we cannot detect successive corresponding logical increases in the scantlings for planking, frames, and keel-timbers, to stand up to the heavier weights and the increased displacement they involved.

The underwater sites studied do not yield fragments of structural elements which show that the scantlings observed the rule that there must be an instant and rapid increase in displacement with every addition to the linear dimensions. Yet empirical experience in the Greco-Roman world ought to have led to an understanding of these physical facts. We may in fact liken the shell of the many wrecks along the French Riviera to the wooden hulls of large-sized modern cruising yachts, yet these fragile ancient hulls carried cargoes amounting to many hundreds of tons. Nor were the dimensions of the planking increased to meet the heavier burdens; where the carpenters found the shell too fragile for the burdens calculated, not heavier, but double, planking was employed[59]. In the Nemi hulls the planking and the closely-spaced pattern of hewn frames represent a fairly modern conception of wooden construction, yet the skin (planking plus frames, stringers etc.) does not match the enormous displacement of these flat-bottomed hulls. The makers of the classification rules for wooden ships in the 19th century would, without doubt, have required a planking with sections increased at least ten-fold[60]. In spite of stiffening elements like floors, keelson, beams and various vertical struts, serious faults and weak points were hidden in the hull of the ancient carrier. The shells were, in theory, tight, with the seams very carefully locked together, but the exposed bottoms were simply too weak to bear the cargoes carried in rough conditions. The amount and gross weight of these cargoes are calculable from knowledge of the number of *amphorae* carried by a given ship[61].

(ii) Floors and Framing

According to modern principles the stiffening elements of wooden hulls are the frames, which keep together the skin from keel to deck-beams, and the floors, which are bolted to the keel and fixed to a number of planks along the keel. By attaching these two systems to each other great strength athwartship was secured. A corresponding method embodying bent planks on hewn frames was known in the Dark Ages, refluted by Homeric poetry in which exact information is scarce, yet implications are numerous[62]. (In European ship-building, starting from the 14th century on the Atlantic coast, floors and frames as well as deck-beams were manufactured together in heavy-timbered 'rings', which were prefabricated in a horizontal position and then set up in the hull.) The importance of the system described is easily understood if one imagines an external ballast-keel fitted to the keel; the momentum of this keel, exercised when the ship heels over, is checked by the complex of elements bolted to the longitudinal keel.

The fragments at our disposal show differences to our modern conception of the functions of the structural elements. In the first place we find floors and frames (in fact half-frames) carefully hewn to fit the planking, our evidence being the tomb-stele of Longidienus which shows a shipwright trimming a piece of timber of heavy dimensions. In fact we cannot be sure about the piece of timber handled whether it is a half-frame or a symmetrical floor. In the second place we find complete (left- and right- side) frames combining the function of frames and floors in the spirit of 'Atlantic carpentry'.

Of the wrecks listed, the County-Hall fragments include only weak frames hewn to fit. In the wreck of the Grand-Congloue (which we know extraordinarily well) we find frames adzed to fine proportions, as well as short floors bolting the half-frames together[63]. The fragment of a floor shows wooden trenails to have been used at these critical points where strength was required. In the wreck of 'le Titan' we find extraordinarily strong frames in one piece, acting at the same time in the capacity of a floor. Fragments giving evidence of similar methods of construction are recovered from the wrecks of le Drammont and Monaco. We find this principle employed also in the Nemi hulls.

In these abnormal pontoon-shaped hulls we find heavy, carefully adzed frames, made up of three pieces. We regularly find a long solid horizontal placed centrally and bolted to the keel. In this case we find frames and floors combined into a single element, a feature which perhaps may be identified as belonging to the 1st and 2nd centuries BC.

The wreck of Pantano Longarini, dated to the 6th century AD, was not published, but from pictures we are able to observe coarse and only partly trimmed timbers used as frames with an extraordinarily short distance between them. In such flat bottoms floors are not required, the practice followed in the Nemi hulls being adopted. From the limited number of photographs depicting this particular wreck[64] which are available it may be concluded that early medieval methods as well as examples of carpentry are to be found in it. These differ completely from the methods of the late Hellenistic/early Imperial period. The present activity in the underwater investigation of early Byzantine wrecks may possibly supply the facts which will enable us to see the continuity between the weak but painstaking carpentry of the Empire and the assembly of untrimmed trunks (of low-quality timber), which apparently constituted an early medieval merchantman.

From the chronological analysis we may conclude that the Hellenistic period knew floors, fixed to half-frames which terminate when they touch the keel timber. We may understand this practice as a heritage from the 4th and 5th centuries BC. As time goes on this method appears to be rationalised with frames, adzed from one piece of wood, replacing the fairly short floors, a practical consequence of the heightened standards of the manual crafts during the early Empire. The practice lingered on when transferred to the flattened hull-sections of late imperial and Byzantine seagoing carriers.

(iii) Keels, keelsons and various bilge-stringers

In the period when ancient ship-building was studied from contemporary literature and representations only the elements listed above, which have important functions in longitudinal support of the hull, were not observed nor discussed. The most important fragment from the ancient port of Marseilles (Galère de Caesar) was virtually unknown. A fragment of the keel is a part of the County-Hall fragment but details were not published. From the wrecks of Antikythera and Mahdia no timbers were raised originally, but in the renewed activity in 1955 a fragment of the keel was brought up from the Mahdia wreck. Investigations in the nineteen-fifties, on the other hand, laid emphasis on hull-elements covered by cargoes. In the Nemi hulls the keel exhibited a very simple and rational section, but this should be seen as a special case consequent upon the flattened bottoms of these pontoon-shaped hulls. As a result of the careful study of the Grand-Congloué and some other wrecks, all of which were published with great merit, interest became concentrated on the main longitudinal timbers: keels, keelsons, and bilge stringers, on their sections, joints, scarfs and respective dimensions.

As we have already seen the keels studied show extraordinarily weak dimensions. In all wrecks studied along the French Riviera the keels have been insufficient to perform their stiffening function, so that movement and leaking have occurred when the ships have been subjected to sagging and hogging. This appears to have been the reason why the keelson was introduced, as observed in the Monaco wreck, where the section area of the keel was about twice that of the keelson, and in the 'Galère de Caesar', where the relation of the two is about the same while in the wrecks called 'Le Titan' and 'Dramont' the keelson is of heavier dimension in comparison to the keel proper (in the 'Titan' about 30% and in the 'Dramont' not less than about 120% of the section-areas of the respective keels). This development which we should prefer to see set in a chronological pattern may possibly be the outcome of increased theoretical knowledge among naval architects, comparable to the interesting efforts of the Yankee 'downeaster' hull-builders in the mid- 19th century to stiffen the softwood clippers[65]. In this same period we find the enormous built-up keelsons fitted with forged diagonal fittings, stays and stanchions'.

Sections of keel are frequently examined from a typological point of view when the study of wooden shipbuilding is pursued in general[66]. In Nordic, late Iron-Age shipbuilding we find the bold but functional T-sections, typical of lapstrake construction in full scale. To 17th and 18th century shipbuilding belongs the extremely heavy composite keels, taking the complete rings of frames, floors and beams, and being given the chiselled rabbet line to take the lowest plank, the garboard strake.

In the wrecks of antiquity here studied we find an ancient version exhibiting keel-sections lacking a rabbet line. The keel in its upper part is cut obliquely to take the garboard strake at its proper angle. The planks are attached to it by the mortise-and-tenon method. Inserted in the keel are robust tenons locked in position by trenails of circular section. This dubious method, in as much as floors securing the planking to the keel-timbers are lacking, was apparently improved by a secondary outer planking of light dimensions. The secondary garboard strake of this outer skin fitted into a shallow rabbet line chiselled low on the keel. This method is, chronologically, older, yet we find it employed in the fairly advanced wreck of Drammont (showing double planking and fully developed keelson). The purpose of double-planking was merely to check leaking seams in weak hulls.

In the wrecks of 'le Titan' and Mahdia we find an improved method employed with the garboard strakes fitted in the way described, yet sunk in the keel timber so that nails can be used in the fitting of the lowest plank to the keel. This method gives some guarantee against the seams opening in a seaway. The keel of the Monaco wreck exhibits a rectangular section and a rabbet line in the spirit of modern wooden hulls. The details of the hull of this ship below the waterline are astonishingly rational and give proof of very advanced carpentry.

In the Nemi hulls we find a rectangular keel-section, extended however sideways in its upper part, so as to show a T shape. Here we find the garboard strakes fixed according to the methods employed in lapstrake, keelless, dories, starting from a plank horizontally placed. This method is well-found, since the flat bottoms of the pontoon-hulls allow the planking to meet the keel at 90°. Unfortunately corresponding material from the wrecks of the late empire is not available. In the case of the very late Pantano Longarini hull fragments of the keel were not recovered.

Owing to the general lack of long timber within the Mediterranean, carpenters encountered special difficulties in putting together keel-timbers for ships of great dimensions, and craftsmen were obliged to join them by means of scarfs. This method of joining is tricky and requires considerable skill. The general weakness of keels, resulting in longitudinal movement, emphasized the importance of effective scarfs. The very limited number of scarfs observed and studied contains mostly individual examples. Only a few scarfs are known from the Nemi hulls: the first ship shows a simple variant lacking strength, while the second ship demonstrates a long scarf with an ingenious locking device including a tenon[67]. The wreck of Monaco (as reconstructed by J.C. Roux) included a scarf of similar construction, requiring a first-class carpenter and measuring tools. This marvellous piece of work may be regarded as marking the peak of nautical craftsmanship achieved within the peaceful and prosperous Mediterranean world of late antiquity.

(iv) Garboard strakes, double garboard strakes and double-planking

The above structural elements are closely connected to the questions previously discussed. In cases where the frames are carried down to the keel and fixed to floors attached thereto, the assembly of these elements will be strong enough to avoid breakage between the keel and the garboard strakes. Should this not be the case, as in the majority of the wrecks studied, the critical seam between the keel and the planking will open as soon as motion starts in a seaway. There are reasons for believing that this very seam caused much trouble. Thus it may be of interest to compare various methods of attaching the garboard strake to the keel. This section refers closely to the fore-going study of keel sections.

Where the garboard strakes are fixed to the oblique keel simply by mortise-and-tenon joints (Grand-Congloue), a heavy load will affect the joints along the keel. This risk would be reduced by floors fixed to the frame, but not completely eliminated. An additional secondary skin of planking was apparently invented by experience with a view to reducing leaks, the inner skin providing structural strength. In the 'Le Titan' wreck, characterised by frames and floors well assembled on the keel-timber, we find the garboard strake fitting into a perfect rabbet line. The garboard strake is further attached to the keel by tenons and mortises, the tenons properly secured by trenails driven through the planks. In spite of these improvements in the interest of strength we find double-planking, carefully covering the critical seam here brought into focus. This secondary planking however exhibits a thickness reduced plank by plank to a mere wooden sheathing. This surface should not be understood as an auxiliary precaution or as repairs.

In the wreck of 'Dramont' we find principles of a different nature. The heavy garboard strakes are attached to the oblique keel (as observed in the Grand-Congloue wreck), but they are properly supported by frames or floors finished to fit the keel. In this case we do not find double-planking but, on the contrary, a complete inner planking possibly reaching to the deck beams. Owing to the lack of a keelson the hold probably showed a groove in the centreline along the keel.

As already mentioned the technically-advanced wreck of Monaco shows a perfectly cut rabbet line to take the garboard strake. The Nemi hulls however, with a T-shaped keel section, have the first plank nailed to the horizontal extensions from the rectangular keel, but nailed on the under side. In this respect they correspond to the early lapstrake ships.

(v) Horizontal or longitudinal supports: bilge- or side-stringers, secondary keelsons and shelfs

The construction of fast oar-propelled vessels presented the ship's-carpenters with problems of longitudinal strength. Special methods had to be employed to strengthen the finely-tapering bows and sterns, since weight had to be kept down as much as possible. Two alternatives were offerred: to reinforce hulls by inserting keelsons and various stringers or external strakes or to employ laid cables, the *hypozomata*, stretched from end to end of the ship. The second alternative was employed on the Nile before Bronze-Age navigation in the eastern basin of the Mediterranean, as tomb-reliefs show[69]. In fact the building of decks in oared vessels is an example of the first alternative: longitudinal strengthening by means of timbers. Unfortunately we lack information about the methods employed to attach the decks to the hull-planking or about the existence of shelf-timbers running from bow to stern.

Our knowledge of the elements listed is confined to the wrecks already examined, as well as to the Nemi hulls. Some information is in fact to be had from representations where we are able to observe the position of the deck beams or the protruding structures accommodating the oars – the *parodos* and *parexeiresia* – in oared war-ships. We do not however know how the deckbeams were secured to the hull-fabric.

In the huge hull-fragment called the County-Hall wreck we can observe a stringer, possibly a bilge-stringer, running fairly parallel to the keel, about 3ft from it at the waist but converging towards the bows. This element is weakly dimensioned, not larger than a frame, and cannot be seen in the capacity of a strengthening member.

In the fragmentary wrecks along the French Riviera we find no secondary keelsons, parallel to the keel, nor heavy bilge-stringers fulfilling the same purpose. Since nothing remains of the upper hulls or of the freeboard parts there are no remains of deck-beams nor of their longitudinal support, the shelf. Whether the number of wrecks located increases in the future or not we have no hope of finding more than fragments of bottoms which owe their preservation to the protection of the cargoes carried.

The Nemi hulls should be regarded as phenomena quite out of the ordinary. The carpentry studied and recorded in detail cannot be regarded as received practice. In each of these hulls we find a centre keel fitted with a keelson, two complete keels oneach side of the centre keel as well as two internal stringers on either side of the flat bottoms. These timbers are not opposite to each other (internal stringer to external keel) but are in between each other. All these longitudinal timbers support the extremely heavy deck-beams which are stepped on short wooden struts. Where the planking reaches the deck-beam level the beams rest on a shelf of weak dimensions, but when they are brought through the skin they rest on a heavy wale, bolted to the frames, which takes the stress. This external wale is an element borrowed from oared ships with protruding *parodos* or *parexeiresia.*

(vi) Deck-beams

We have repeatedly stressed the regrettable state of the wrecks studied with the upper parts eroded by teredos. According to recent publications deck-beams are found in the Nemi hulls and in the Pantano Longarini wreck (fragmentary) only.

The extraordinarily heavy deck-beams of the Nemi hulls, which supported a luxury surface of bricks, marble and mosaics surmounted by light wooden pavilions, are not to be compared with the deck-beams proper of a sea-going cargo carrier. We observe however a total lack of positive curvature in the beams which may reflect customary practice. Also in the marble column-bases made to resemble large-sized cargo-carriers exhibited in the Museo Nazionale and the Museo Torlonia (Rom.7), the broad maindecks (from which the column-shafts spring) appear almost flat.

The single fragmentary deck-beam of the Pantano Longarini wreck is almost round, undressed and lacking the flat surface facing the planking above. It once protruded through the skin and was cut at this point, thus lacking a support. In the Portus relief we observe four such beam-heads carried through the planking skin, square in section, in each hull. These heads carry a horizontal timber, possibly partly sunk in the beams. This timber may be regarded as a locking element keeping the planking tight. If the deck-beams are not sunk into the shelf nor bolted to it, nor attached to it by internal hanging knees, such a 'stopper' common to all the bearing-heads was an absolute necessity in keeping the sides together.

In the tomb-*stelé* of Longidienus (now in Ravenna) which shows a fully planked hull, we find two such beam-heads. In the Ostia sarcophagus (now in Copenhagen), which shows three carriers manoeuvring, we find only one such head in each ship close to the catheads. Such details are not recorded in the graffiti listed in our representative material, nor do the artists of the Sousse or Themetra mosaics pay any attention to such minor details. The coarse mosaics of Ostia are far too schematical to represent things of this order.

(vii) For generations the oar-systems as well as the distribution of oars-men in oar-propelled warships was a matter of dispute, yet never properly explained. The sailing ship possesses one feature common to the oared warship in the outboard structure which serves pivoted oars, yet steering oars only.

As true representatives of such protruding platforms, built on extended beams exactly at deck-level, we may see the column bases (Rom.7) which are in the form of ships exhibiting these details. The outboard deck begins forward of the waist and is gradually broadened towards the stern until it ends along a line set at 90° to the centreline. The supporting baulks are either extended complete deck-beams (Nemi) or a set of hanging knees or consoles trimmed to fit the planked curving hull[70].

In the carriers represented in the Portus relief (Rome10) we are able to study the platform from the side, apparently in correct relation to the heavy beam-heads visible which indicate the actual dimensions of the deck-beams. In the Ostia sarcophagus (Rom.12) the platforms are indicated but from the ships represented we get the impression of broadened decks starting immediately from the bollard on the foredeck. The side-rails/ bulwarks appear to follow the outer edge of the broadened decks. This is further confirmed by T 8 (Rom.21), a large-sized carrier from the large floor mosaic at Themetra, where the rails/bulwarks are depicted on the extended deck aft from the artemon mast. Other ships represented in these African floor-mosaics exhibit a peculiar blend of sail- and oar-propelled vessels with a fully developed 'shelf' for the oars, the *parodos,*but these are not relevant for study.

The opinions here presented, backed by the best representations of carriers at our disposal are unfortunately not confirmed by underwater fragments. From the Nemi hulls we learn how outboard extensions of the deck are built in relation to the maindeck, and also the principles for the planking in of these structures. At the same time these outbuilt platforms cannot be seen as representative of the sea-going cargo-ship. We revert to the details of these outboard structures when we concentrate on the problems of steering.

(viii) Bows and sterns: timbering and planking

Of the bow and stern structures which artists and coin designers show with such eagerness, no fragments have been recovered. One exception is the putative bow of a Punic oared ship brought to the surface in western, Carthaginian, Sicily. Certain timbers have been identified as fragments of bows or sterns, but in the final descriptions of wrecks excavated such timbers or fragments are never found listed. The Nemi hulls, which held abundant fragments and debris of structures on and above the 'garden-deck', were reconstructed as warships with the traditional decorations. The bow of the first ship was reconstructed with the beak or ram and a wooden decoration curving aft. The second ship was given a similar bow, and the *aphlaston* of the stern of the oared ship of classical pattern. Feeble wooden fragments and the bronze sheathing, cast in three pieces, of the decorative profile above the beak were combined and put together in a hypotheyical reconstruction when the ships were brought into the sheds. This bronze sheathing[72] with an U-shaped section (which had been partially raised when the drying out of the lake-bottom in the 19th century enabled attempts at recovering the wrecks to be made) is in fact the sole evidence for the existence of the curved wooden decorations, apparently difficult to render in wood. The concave curve corresponds to profiles shown on coins from the Hellenistic and Roman world[73]. The inner dimensions of this sheathing show the curved stempiece to be reduced in thickness to 50% at the top, evidence for a clever reduction in weight. The sheathing is fitted with a total of ten (five plus five) tongues turned sternwards for fitting to the timber. There are no holes for bolts. This very interesting fitting, which survives solely in Uccelli's book, is relevant to the oar-propelled vessel but also to some extent concerns the sailing ship too, as there are two distinctly different types of bow in late antiquity: that with the convex profile ending in a cut head, and the beak bow with the profiled timber curving backwards and frequently ending in an *akrostolion.* If actual remains of such fashioned timbers are discovered in future, reference may be made to the bronze-sheathing from Nemi.

The conclusion is that remains do not exist which could enable reconstructions to be made of the stems and sterns of seagoing cargo-carriers. On the other hand we have numerous representations of considerable value exhibiting fine details of complicated carpentry. From literary sources there emerge only stray facts of dubious value from the point of view of carpentry and hull-design.

The real problems are practical: how did the carpenter build the difficult ends of the hulls? We may concentrate on the long curved sternpost, on the very complicated gathering together of the planks along the rabbet, which would require wedge-shaped ends and the use of the plane. We may approach the equally difficult bow-design which embodied the ram or beak, and try to comprehend the extremely difficult planking above the beak, with its complicated curves and planks subjected to heavy torsion, requiring the steaming of timbers. To such questions no answers are given by the underwater sites and the collections of wreckage. Nor have the well-preserved Nemi hulls delivered any answers to our questions, with the exception of the above-mentioned bronze-sheathing, as a 'shadow' of timbers corroded and vanished.

A CONCLUSION

From as late as the early nineteen-fifties true remains and fragments of ancient cargo-ships brought a major change in the methods and approaches of ancient maritime research. The philological approach lingered on as before, allied with surveys of the representations of ships in contemporary art, but was soon to be replaced by archaeology. The purely theoretical debate, alien to practical naval architecture and ship's-carpentry was soon transformed into a technical discussion of real functions in real ships. As we have seen in the foregoing study, underwater sites have yielded material of carpentry of a high technical standard, yet hampered by tradition and by the retention of apparently very ancient methods and principles of carpentry.

Examination of the material recovered from underwater sites, including the Nemi hulls, and also of some chance information provided by 'dry' sites, has now put us in possession of facts about various problems in the practice and methods of ship's-carpentry. These have so far been limited to details only, since the fragments of structurally important elements that have been observed and studied so far have been inadequate. On the other hand we may regard the methods observed in the planking of hulls as thoroughly studied and understood, since the stiffening elements placed athwartship, mainly floor timbers, are generally better preserved and their intended functions better understood. As far as the parts of the hull above the waterline are concerned we have no information from underwater sites, except in the case of the Nemi hulls.

A final assessment of the importance of the material raised from underwater sites must concede that it cannot alter the general picture pieced together from contemporary art, applied art, graffiti etc. A relieable representation of the sail-propelled carrier of late antiquity cannot be put together from the debris of innumerable wrecks. On the other hand contemporary art must have remained mute on the subject of ship's-carpentry and the principles of structure until the material recovered from the sea made possible a new understanding of the pictures in mosaics, graffiti etc., and enabled their value to be properly appreciated.

NOTES TO CHAPTER III (d)

58. Oakum or corresponding organic material is never mentioned in the reports.
59. Double planking applied by nails was observed in the wrecks of the Grand-Congloue and Le Titan. See Benoit: Sections of keel-timbers.
60. Compare the late 19th centuries rules for the building of wooden ships issued by the (French) Bureau Veritas.
61. The *amphora* was the all-important container of antiquity. Its actual net volume and weight differed in the various districts of production. The British School at Athens coordinates the study of shapes, factory-marks and labels issued by exporters. Volumes of 19-26 litres correspond to net weights of 10-16 kilos. The carrying capacity of a cargo-vessel was given by a round number of *amphorae*. Benoit, op.cit. p.163, approximates the Grand-Congloue ship as follows: about 200 metric tons loaded, displacement, about 140 cubic metres cargo-space which is the equivalent of 300 *amphorae* @ 36 kilos. The approximate gross weight of the cargo carried is 108 metric tons.
62. Od.19 574-5. A literal translation is as follows (Penelope speaks) 'I will arrange the areas as a contest, the axes which Odysseus used to set up a line in his hulls, like timber-rests, twelve in all.' From other passages in which the word *druochoi* (timber-rests) appears, it seems that the first stage in shipbuilding was to set out these timber-rests. They are thus taken to be wooden pegs on which the keel was aligned. There is nothing in Homer about frames.
63. Benoit op.cit. Figs. 75, 130.
64. Throckmorton-Kapitän An ancient shipwreck at Pantano-Longarini. See the sketch of the excavated hull-remains (a fragment of the stern only), most probably demolished by the Sicilian landowner.
65. Not possible to document from the drawings/sketches now available, but is understood from the study of the rules for wooden ships.
66. Compare Nordic Iron-Age shipbuilding: Ole Crumlin-Pedersen 'Treaskibet fra langskib till fregat. For Nordic medieval shipbuilding: Harald Akerlund, 'Fartygsfynden i den forna hamnen i Kalmar' Kulturhistoriska under sökningar vi Kalmar Slott Pl.1-30.
67. Uccelli, *op.cit.* See attached drawings Tav.VIII showing timbering, the principles of planking etc. See also Sezione Longitudinale.
68. Benoit, *op.cit.* Figs. 79 p.146.
69. *L'Illustration:* Histoire de la Marine ed. L'Illustration, p.17: a tomb-relief at Deir el Bahari.
70. Uccelli, *op.cit.* Fig. 293. A Roman bireme. See also Casson *The Ancient Mariners* pl.10.
71. Uccelli, *op.cit.* Fig. 113: a model of Ship I.
72. Uccelli, *op.cit.* Fig. 151.
73. Compare the coins reproduced by S.L. Cesano 'Commento storico-archeologico alle Monete da Nemi" pp. 357-368: an appendix to Uccelli, *op.cit.*

CHAPTER IV

The Steering Oar in Late Antiquity

(i) Technical development before the Hellenistic age

For the study of the design of the rudder in Greco-Roman sailing cargo-ships at least some knowledge is required of the development of rudder-design from the IV-V Pharaonic dynasties in Egypt[1] to the 7th century in Greece[2] within the eastern basin of the Mediterranean. From a technical point of view this development appears insignificant as far as the handling and mounting of the rudder-oar is concerned. Yet the outlines of this development should be recognised as important links in the chain of continuous evolution which ends only in the period of the Crusades when rudder oars were abandoned. Early Egyptian shipbuilding is well documented by a multitude of reliefs in rock-cut tombs[3] as well as by a considerable number of ship-models[4] which occur among standard Egyptian grave-furniture. Both types of representation allow a close study of river as well as of seagoing craft. River craft, with or without a sailing rig, from the IVth dynasty (represented by reliefs in the tomb of Merab[5], a son of the Pharaoh Chufu) and from the Vth dynasty (represented by a rock-cut tomb at Sakkara[6]) exhibit two or three oars fitted to ships' sterns, probably on both sides of the hull. These oars very much resemble the javelin-shaped oars used in the early period for paddling, later for rowing proper. The hieroglyph 'Chen' depicts two human arms handling an oar like a paddle[7] and is regarded as evidence for the extreme antiquity of paddling. The steering oars, however, are longer than paddles and handled freely, i.e. without any straps or lachings whatsoever. During the Vth dynasty these oars were apparently attached or pivoted to horizontal timber wales marking the deck-line. The angle between the oars and the surface of the water here exceeds 45° which implies that the oars must be turned when attached (not swung from a pivot). The total working surface of these oar-blades was small; yet each oar required a man, a most uneconomical arrangement. During the last dynasties of the 'Old Kingdom' (2300-2160 BC) these lancet-like oars seem to have been found inefficient and were replaced by oars with a much increased surface, fitted in pairs on each side of the hull abaft the point at which the up-ward curving stern emerges from the water. Oars fitted in this way are to be found in the 'Punt ships' of Queen Hatshepsut carved in the royal tombs at Deir-el-Bahari[8]. The elongated oar-shaft is fixed by a strap at deck-level but also rests on a vertical wooden pillar, hollowed to take the shaft which in turn is properly lashed. At deck-level a horizontal baulk, laid athwartship, protrudes on both sides. The oars are attached to this baulk by, apparently complicated, lashings. It may be regarded as an embryonic 'outrigger' for the steering oars. This method of attaching the steering oar by relying on two fixed points is confirmed by a model of a luxurious river craft with rigging, steering-oars and the painted decoration intact, from the tomb of Tuth-ankh-amon[9]. The oar is turned on its axis by a tiller-shaft fitted into a socket in the oar-shaft and pointing downward towards the deck.

Parallel to the method of mounting the rudder-oars described, we observe a single heavy steering-oar fitted at the centre-line of the craft and attached at two points, viz. at a support fitted close to the stern timber and at a wooden pillar or biped support. The angle between the oar and the surface of the water is here about 45°. The oar is turned on its axis by a tiller-shaft pointing downwards and is further secured by a strap fitted above the submerged blade which would enable the blade to be hoisted. This principle is demonstrated by two models belonging to the tomb-furniture of Sedment[10] dated about 2100 BC (Plate XX). Köster shows models with a similar fitting[11] but omits to report his sources. With a sufficient blade-area this method was certainly the most efficient in as much as the rudder here worked in symmetric turbulences behind the stern-timber. The angle between the pivoted oar and the surface of the water was here less than 45°. This method was apparently not common, the outrigged arrangement, which was open to visual inspection and was therefore to be relied on, being preferred.

The Phoenicians avoided showing their ships in representations which were intelligible, with the result that only Egyptian representations of Phoenician ships are available in this period[12]. Thus the representations of these vessels and their technical details such as steering-gear may well be influenced by Egyptian conceptions when they appear in relief sculpture.

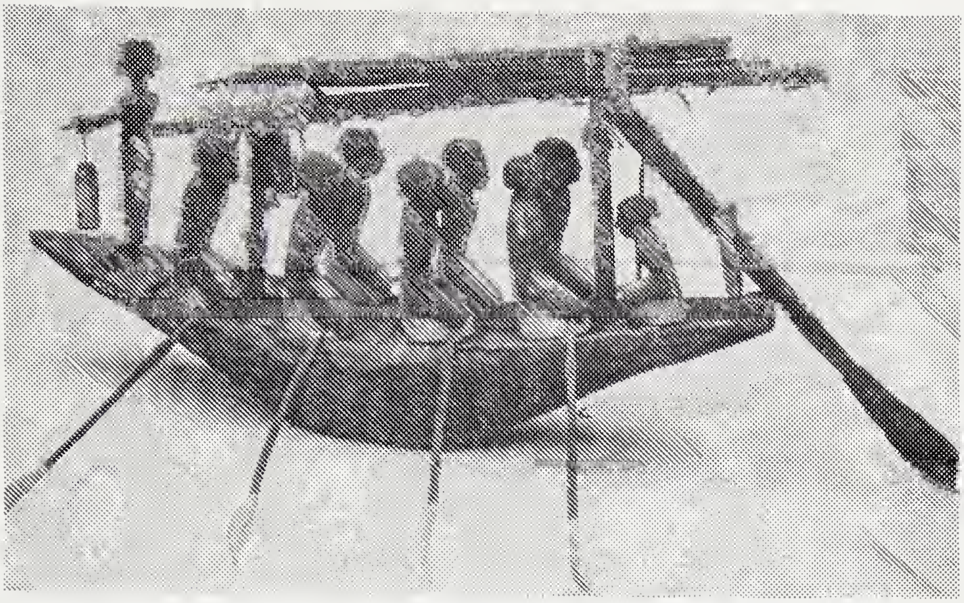

Plate XX An Egyptian boat-model from a tomb in Sedment, 2100 B.C. Ny-Carlsberg Glyptotek, Copenhagen. This oar- and sail propelled river craft is steered by a single pivoted steering oar arranged in the centreline; an alternative to numerous oars fitted to starboard and port.

(ii) The steering oar in Greco-Etruscan ship-building

The steering oar of Greek vessels frequently appears in vase-paintings and also on painted terracotta plaques and pinakes. The point has already been stressed that only oar-propelled hulls attracted the interest of painters working for a large popular clientèle.

On a plaque in the proto-Attic style we find the stern of an oar-propelled vessel which has a raised central gangway accommodating five hoplites protecting themselves with circular shields. The hull exhibits a heavy steering-oar. Possibly the artist intended to show the port and starboard steering-oar simultaneously superimposed one upon the other. The details of the fitting are unclear, but it seems that the oar is strapped only to the wale, not fixed at two points by the Egyptian method.

On the krater signed by Aristonothos both ships shown are carrying oars with rectangular blades, apparantly made up of several elements.

In a fragment of black-figure Attic ware from about 550 BC (Plate XXI) we are lucky to have detail of the attachment of a steering-oar at a single fixed point by a cross-lashing. In the black-figure fragments of *dinos*-type[13] signed by Exekias we find oars with a rectangular blade fitted at a single point, apparently to a hollowed wooden clamp. In the well-known picture by Exekias of Dionysios in a ship, on a vase now in Munich, the steering oars pivot from one point and lack tillers.

The oared ships depicted on black-figure *dinoi* by the Leagros group of painters[15] exhibit very heavy and clumsy rudder-oars, but no details of fittings. In the very rich material from the archaic period we are able to note considerable differences in the angles described by the steering-oar and the floating plane. A red-figure *stamnos* from the late archaic period (Plate XXII) shows an oared ship with a very short steering-oar with rectangular blades. The oar is fixed to a wale supporting the rowlocks, and is cross-lashed. In the whole material of Attic vase-painting recorded we are unable to find any example of oars fixed at more than one point. These representations, however, do not give any information about the actual method of attachment: e.g. do the oars rest against two horizontal wales, or against wooden clamps fitted to these timbers or protruding from them to take the oar? There is reason to believe that something like these possibilities was the case, i.e. that the rudder-oar rested in a U-shaped groove in the wales (or in the clamps attached to them) and was lashed to some fittings between the wales and thus pressed against the 'bearing'. Wear appears to have been considerable, thus making necessary leather-sheathing of the shaft at least in ships constantly at sea. In the cargo-ship represented on an

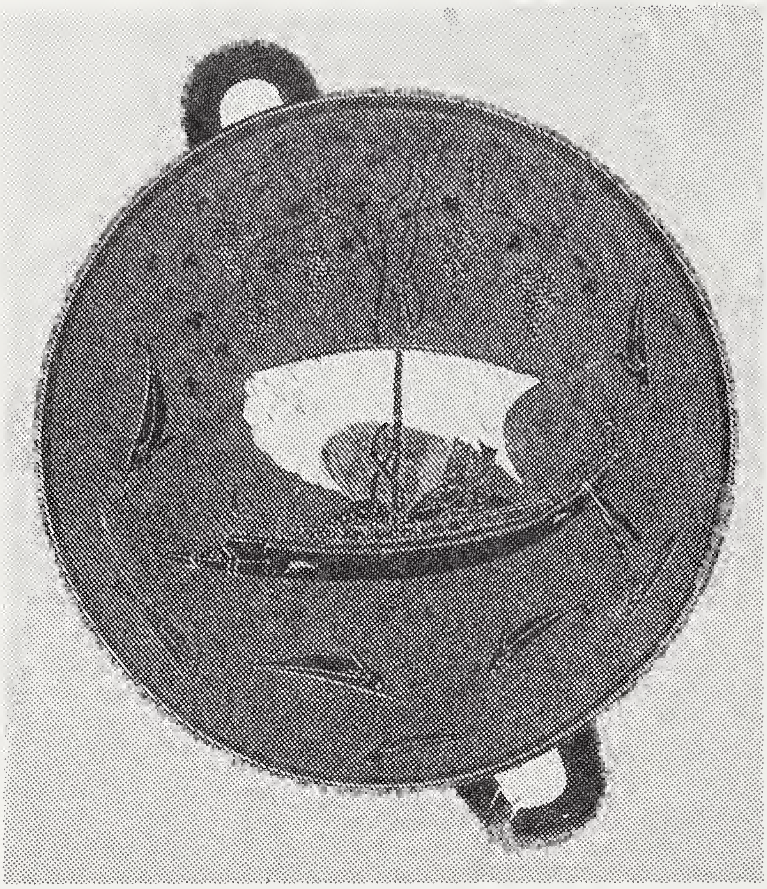

Plate XXI
A blackfigured attic kylix by Exekias, Abt. 530 B.C. Dionysios ship crosses the Aegean. Observe the peculiar manner in reporting the curving of the sail at the leech. The braces are doubled. The ship is directed by the gods will as no one handles the steering-oars.

Attic kylix (Arch.3) we find this sheathing appearing as a spiral above and below the lashing. Unfortunately in the second cargo-ship shown the painting here is defective.

The cargo-carrier shown in the wall-painting in the Etruscan 'Tomba della Nave' (Class.1) is fragmentary, since the mural has been affected by damp, but fortunately the steering-oars and the related hull-section is well preserved (Plate XXIII). We must however take into consideration the fact that the mural has been heavily restored. The actual fitting of the oars is not shown but the rail with its closely spaced stanchions shows a bulge outwards at deck level thus affording protection to the oar-shafts at the critical point. This feature betrays an interest in safeguarding the rudder-oars with various structures. The oars here may possibly have rested against a protruding baulk or a heavy clamp. Up to this point in the historical development of the fitting of the steering-oar its details have been visible in such representations as have survived. But from the 5th century onwards we find that a rail or planked bulwark, later a structure protruding sideways from the maindeck for the sole purpose of taking the sterring oars obstructs the view of the critical area of the hull.

If we have to rely on the material at present at our disposal we are unable to follow the development of the use of steering-oars during the classical and Hellenistic periods. The fine rock-carved relief dedicated to Hegesandros, which flanks the stairs leading to the Acropolis at Lindos[16], shows the mounting of steering oars on a light warship in the early Hellenistic period. The oar is fitted to an open outrigger, apparently to a baulk placed athwartships at deck level marking the limit aft of this planked platform. The rudder-oar is shown hoisted to rest horizontally, but the part showing the actual mounting is unfortunately heavily damaged. This area of interest is, further, covered by a rail or lightly planked-in bulwark, according to the practice already mentioned. The blade of the oar is asymmetric, with the greater blade-surface aft, and is of a very elegant shape.

The ship shown on the short end of the so called Conteneau sarcophagus excavated from the site of Sidon (Hell. 1) is typical of the very last period of the Hellenistic age. The mounting of the steering-oars indicated the principles of late antiquity, although in fact the ship approximates to those of the early Empire. Here the oars are fitted to an outrigger protruding not from deck-level but from the level of the lowest rubbing-strake

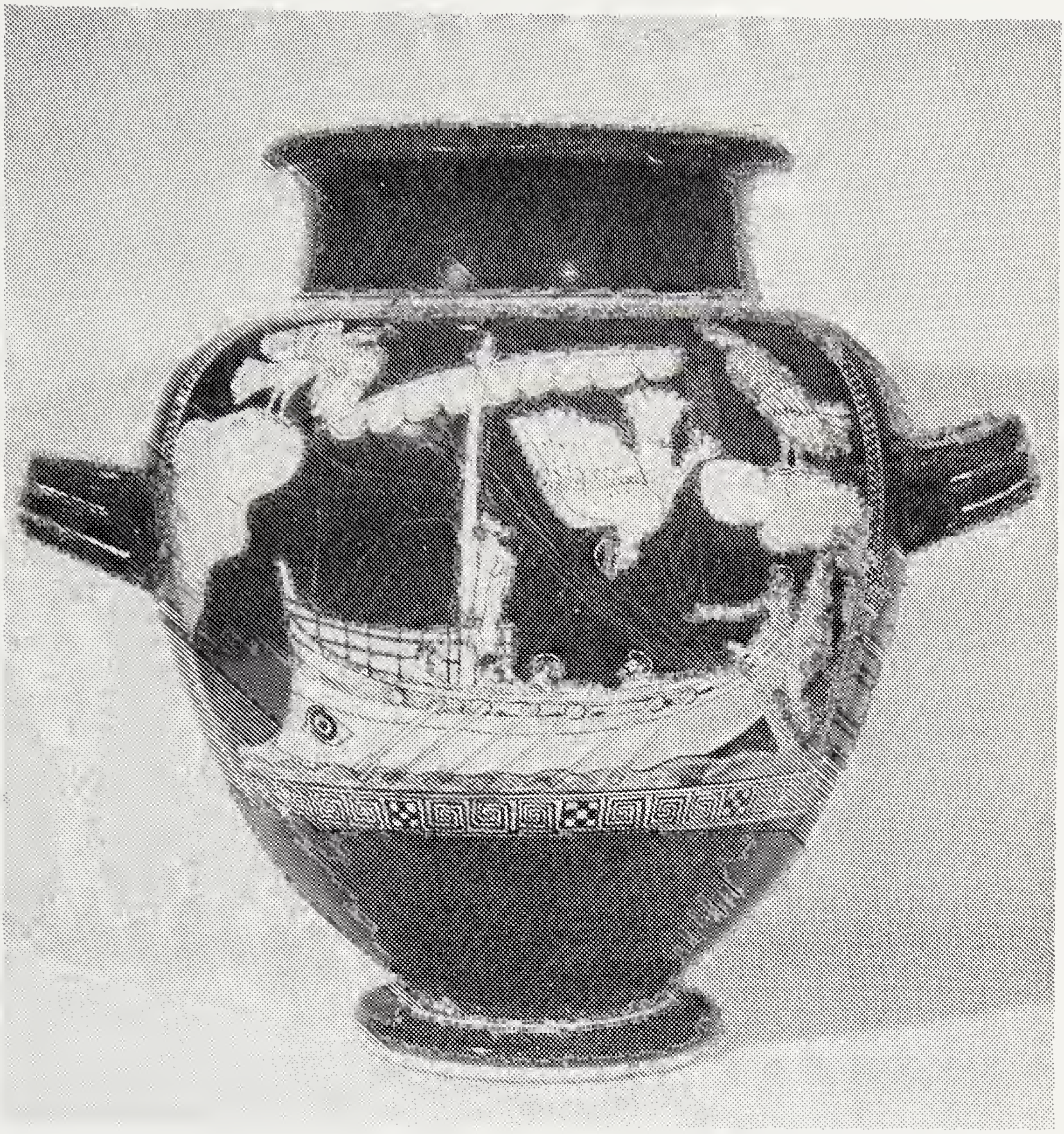

Plate XXII A redfigured attic stamnos by the “Sirene-painter”. 520-480 B.C. Br. Museum E. 480. Odysseus and the sirens. The sturdy moner carries a heavy polemast provisionally stayed. The yard is supported by double halliards taken through eyes in the (cast ?) bronze masthead fitting. Buntlines, braces etc., are all brougth to the helmsman place. The steering oars are secured to the vale by seizings. The oars are apparently turned without tillers

covering the freeboards. The rudder-oar may here be attached at two points or alternatively carried in a U-shaped groove. In any case the mounting is firmer and of a more permanent nature than those shown in archaic vase-paintings. Nothing however is shown of the straps or lashings employed. Relevant texts show that rudder-oars were hoisted in when it was necessary to protect these fairly fragile things. The shape of the blade shows that they were made up of several pieces. The shape of the blade was symmetrical like those of later cargo-carriers. The advantages of the asymmetrical blade would have been theoretically apparent to ship's-carpenters and naval architects, in making the wake bring the blade back to a neutral position when the rudder-oar was eased by the helmsman.

(iii) The steering-oar in Roman ship-building

The sailing cargo-carrier of late antiquity appears in the various representations listed above. The evidence they provide is acceptable since the subject was fairly well understood by the artists employed. Gross exaggeration of nautical details is not normally found in objects of art, but exaggeration of human figures in addition to ship's is frequent.

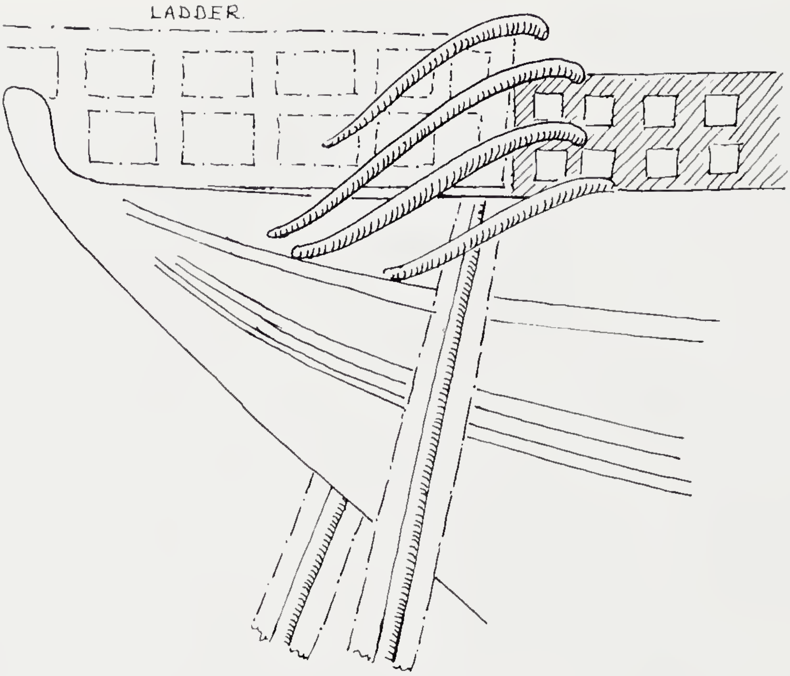

Plate XXIII (a) The stern of the two-masted ship represented in the murals of the "Tomba Della Nave" in Tarquinia. This sketching by the author tries to clarify the details of the badly corroded but restored surface: the permanent rail (right) continuing as battens governing the oars, and a ladder stowed aft.

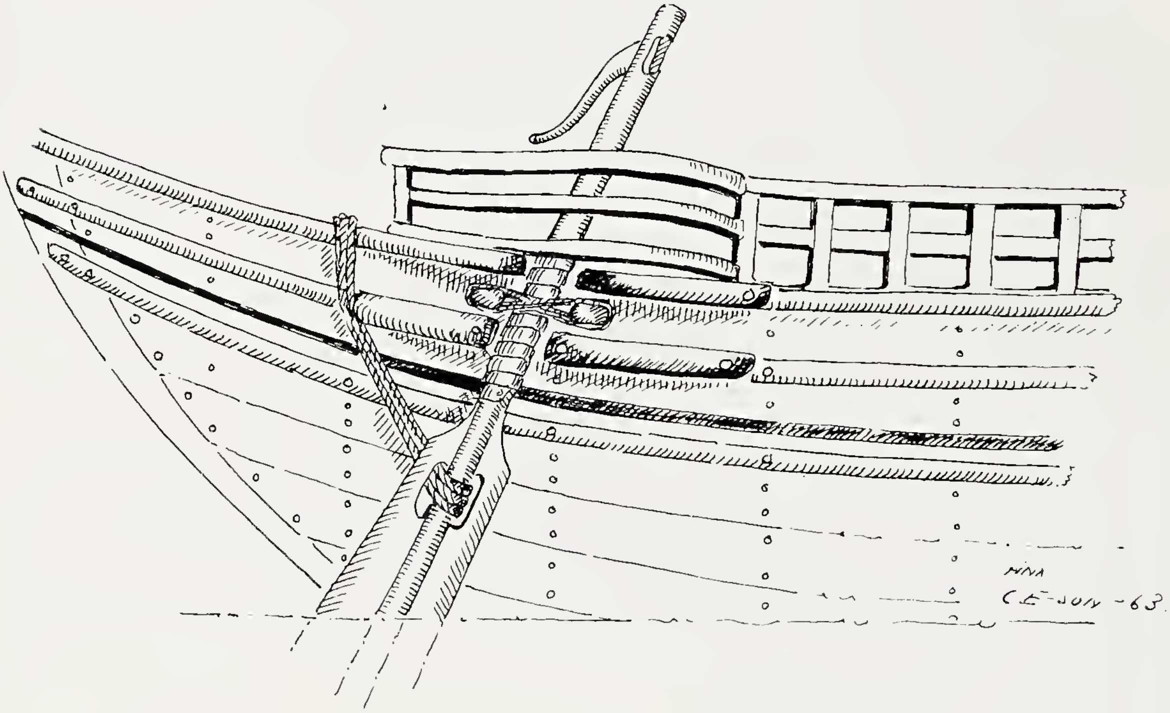

Plate XXIII (b) The stern inclusive the steering oar of the ship in the "Tomba Della Nave," as interpreted by the author. The oar, sheathed with leather, is fixed by a seizing and secured by a lifting strap rown through holes in the blade.

Of the reliefs, mosaics, etc., which are relevant to the steering-oar only the Portus relief in the Museo Torlonia, the Ostia sarcophagus in the Ny-Carlsberg Glyptothek, the relief inserted into the wall of Salerno cathedral and some of the floor-mosaics from Sousse in the Bardo Museum are of real importance to our study.

Reliefs:

The Portus relief (Rom.10) shows the steering-oar as permanently fitted to the outrigged deck at an angle steeper than 45° to the surface of the water, the actual attachment being hidden behind a sturdy, relatively high bulwark. For practical reasons the shafts cannot be mounted at two points but it is possible that the oar-shaft may ride in a U-shaped groove made up of heavy clamps. The tiller shafts are here so fitted to the boom that they point towards the roof of the cabin where the steersman is. The roof of this deck house corresponds to the poop of 19th century clippers. The oar is composed – on the long roof of the half sunken deck house – of a shaft and two blades made up of several planks. A heavy lashing is taken round the shaft through semi-round holes in the blade-halves, rove from the inner side of the oar. This lashing or strap acts as a hoist for the oar, governing its angle and the degree of immersion. It is clearly visible behind the oar and appears to have been belayed inside the bulwark. (Plate XXIV (a))

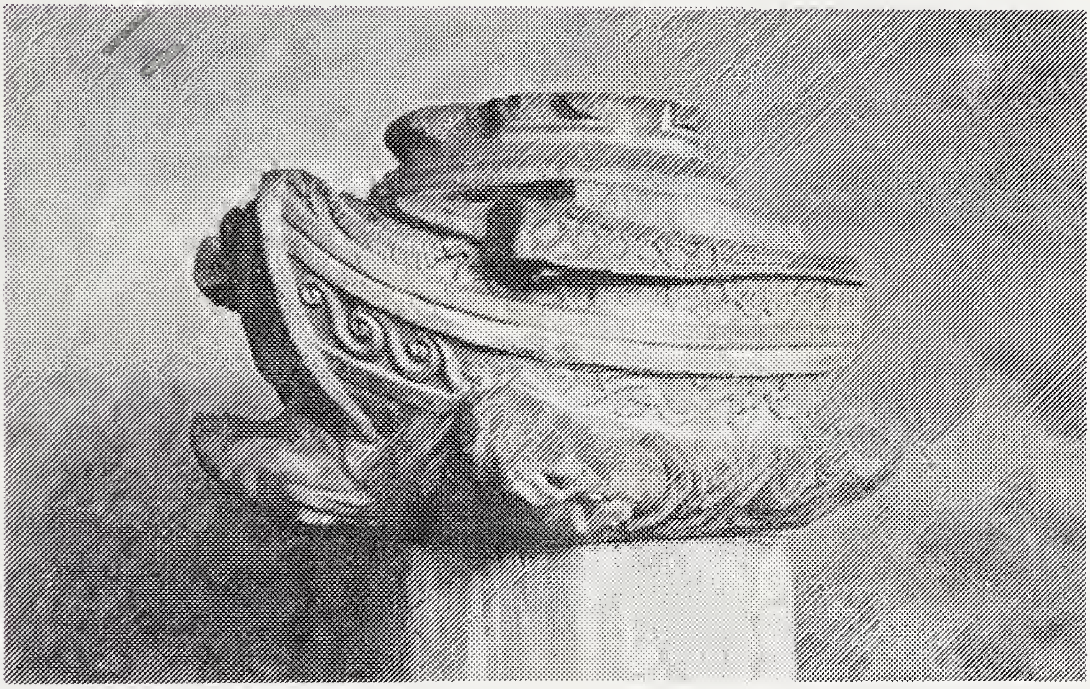

Plate XXIV (a) A base for a column sculpted like the hull of a "Corbita" riding high on waves. Excavated from the Portus Augusti, Museo Nazionale, Rome. Owing to its function the base is elaborately decorated. Observe the outrigged deck with a rail increasing in height governing the steering oar and its fitting to the protruding platform

The Ostia sarcophagus (Rom.12) provides valuable details but is less informative as to the steering-oars. The hoisting-strap above mentioned is visible in three of the steering-oars shown but the function is not clear. The tiller-shafts are here swung towards a helmsman placed aft of the oars themselves. The artist plainly deviates from reality in representing the crew on a superhuman scale.

The Salerno relief (Rom.13) shows a Roman coaster of the *'navis codicaria'* type. The outrigger protrudes from deck level but the steering-oar is depicted schematically. All the details above and inside the bulwark are hidden.

In addition to the above factual representations we should also consider a decorative relief detail carved on a marble entablature (*epistylion*), excavated and set up in Roman Corinth[17]. (Plate XXIV (b) Within a circular frame of fruit and leaves the artist has placed the stern of a cargo-ship with *cheniskos,* the rudimentary gallery and the steering apparatus (with the helmsman). The representation is simple and the workmanship crude, but the principle is interesting. The artist here takes the shaft of the steering-oar through a heavy wooden clamp fitted at deck level, implying a fixed mounting which for practical reasons was not possible. The arrangement shown should not therefore be taken seriously.

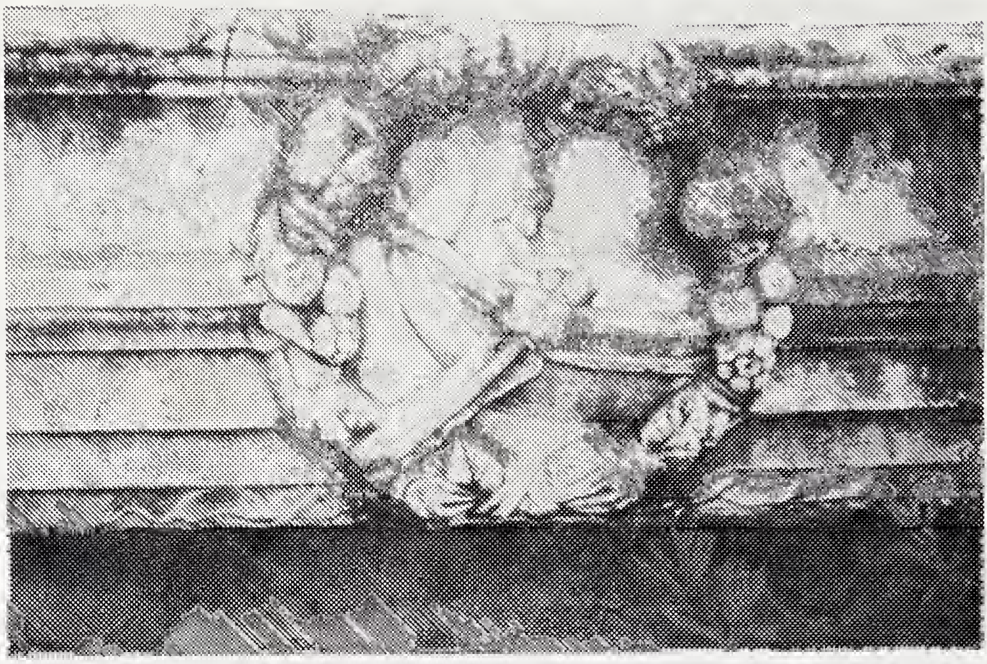

Plate XXIV (b) Fragment of marble entablament with a ship representation circled by a fruit garland. Roman art probably 2d cent. A.D. In the Agora-area of Roman Corinth. The stern of a cargo carrier with a steering-oar apparently fitted to a solid block of wood.

L. Tursini's Interpretation

In a technical appendix to Uccelli's study of the Nemi hulls Luigi Tursini makes comments on Roman shipbuilding with relevance to the excavated hulls, but taking into account also the state of knowledge of the subject in between the World Wars. He deals partly with the difficult problems presented by oared vessels and partly with the technical arrangements of steering-oars in general. A single, port-side, steering-oar, showing the wooden mortises securing the blade -areas to the shaft, was recovered from the mud covering the wrecks and the bottom of the lake. Fragments were also found of the outrigged platform. The baulk furthest aft showed considerable wear and tear. The steering-oars fitted to it at an angle of 45°.

Relying mainly on the Portus relief but with no support from the Nemi material Tursini puts forward a proposal for the arrangement of the steering oars[19]: a solid piece of timber tilted at 45° and shaped to fit the stern was bolted on to take the oar-shaft, its outer surface enabling the oar-shaft to be lowered parallel to the keel. A U-shaped groove was hollowed in the timber to act as a half-bearing, the oar being prevented from slipping downwards by a ball-shaped hub (left when the oar-shaft was shaped) which rested in a corresponding cup hollowed in the neck of the bearing. To prevent the oar from wobbling, Tursini invents a wooden pivot above the waterline, possibly a baulk passing through the planking, and the oar rests against this lower secondary support. Tursini further suggests that the afore-mentioned hoisting-strap, rove round the shaft through holes, was taken through an opening in the pivot and back to the deck. He does in fact double the strap by taking both ends to deck level. By tightening or easing the strap the turning of the oar and the necessary power is adjusted. When raising the oar either in port or in rough weather the strap is eased and paid out. Considering the difficulties in lowering and bringing into action the oars offshore, after a period of drifting with sails furled and steering-oars hoisted[20] (as frequently happened with the large carriers), Tursini's proposed arrangement is very practical and workable, especially in the case of hulls with a heavy displacement where all operations required a great deal of muscle-power.

The Nemi hulls –

Around the two big hulls and among the vast material recovered was found evidence that the steering-oars were mounted against a horizontal/baulk in the outrigged platform, at an angle of 45° to the surface of the water[21]. The shaft here pivots at a single point, since a secondary lower pivot (as in Tursini's proposal) is out of the question with an extremely low freeboard. There are no remains of the lashings fixing the shaft to the outrigger. Details not observed in the reliefs and mosaics etc., are the heavy timbers covered by artistic bronze fittings protruding from the outriggers. These clamps are interpreted as stoppers to keep the oar-shafts in position[22]. This suggestion is not confirmed. In relation to the displacement of the hulls and the momentum produced by the movement of such masses the arrangement of the rudder-oars is fragile and primitive, corresponding to the extraordinarily light scantlings of the immense hulls which appear to have been timbered in accordance with the structural dimensions of contemporary light oared ships. The Nemi hulls and the vast material recovered and recorded by Tursini add nothing to our knowledge in respect of the steering 'machinery'.

The Floor-Mosaics from Hadrumetum and Themetra –

These mosaics from Roman baths now in the Bardo Museum (Musée Alaoui) compose a large-sized floor with a head of Neptune in the middle and various nautical themes arranged around it (T 7 and T 8), as well as steps, covered in mosaic, leading to the *frigidarium*. These mosaics, together with others unearthed in El Alia and Oued Blihane, are published by L. Foucher[23]. In 1905 a study concentrating on similar mosaics from Althiburos had already been published by P. Gauckler[24], and the same material was re-examined by P.M. Duval in 1949[25]. Mosaics of a maritime nature were handled by several French authors, either classical scholars or men with a naval background. These learned activities are exclusively French, taking no account of the Anglo-Saxon and German literature, and are unfortunately in turn almost unknown to students of maritime history.

The cargo-ship S 2 is in fact seen from the side, in profile, yet the outrigged platform to take the oar is shown in such a way as to make the steering oar disappear into a dark empty square, the artist here appearing to use a kind of perspective and to show what in fact would not be visible in profile. The shaft of the oar is not visible above the bulwark. Although he has exhibited many decorative details, the artist has not given us the cue to the mounting of the rudder-oar.

The cargo-ship T 7 is shown floating extremely light. Her stern rises to such a height above surface of the water that the steering-oars cannot reach it. The fitting of these oars is completely hidden by the bulwarks, but the tiller shafts are shown meeting, so that they could be handled simultaneously by the helmsman.

The cargo-ship T 8 should be regarded as a most reliable representation of the largest existing type of carrier in late antiquity. Here the bulwark continues forward of the stepping-point of the artemon-mast. Beginning forward at the height of a single plank it is successively increased until it is the height of three planks when reaching the outrigged platform. The steering-oars fitted at a steeper angle than 45° to the surface of the water are hidden behind the bulwark. The shafts of the oars are visible rising above the bulwark, and the tillers are to be seen converging towards the helmsman.

The fitting of the oars corresponds to that observed in detail on the Portus relief in the Torlonia museum. There is reason to bear in mind Tursini's suggestion of the steering-oar fitted in a groove or half-bearing with a protruding pivot at a lower level.

La Roerie's Interpretation –

In this special connection there is good ground for taking into consideration the French studies of the problems discussed: *'Le Gouvernail dans l'Antiquité'*[26] by Commandant Carlini, an unfavourably criticised study by Commandant Lefebvre des Noettes[27], and finally various studies by Commandant Guilleux La Roerie[28], frequently cited by Foucher. Foucher's arguments are based on a number of French and one Italian author only. He pays much attention to the opinions of La Roerie. As to the steering-oar (le gouvernail) he presents the following theory: at the level of the stern outrigger the cylindrical oar-shaft is carried in a corresponding hollow (a bearing) in a short horizontally arranged wooden clamp, in which being cylindrical it is able to revolve.
La Roerie further arranges the horizontal clamp to pivot (i.e. to turn in bolts or bearings resting on the outrigger) thus permitting the immersion or raising of the steering-oar. The suggested arrangement would permit a simultaneous dipping and turning of the oar operated from above the clamp-hearing pivoted at the stern outrigger. La Roerie maintains that this hypothesis which is technically feasible and an almost perfect solution to the problem, is to be derived from the mosaics. Of these only S 2 may be regarded as supporting the theory of

a horizontally arranged pivoting clamp, yet ample allowance has to be made for free fantasy. We may here well refer to Cecil Torr[29] who rejected an amateurish solution to the enigma of the trireme with the words: 'We are not interested in suggestions how to design a trireme, we simple want to know how these ships were in actual fact built'. A view of this kind should be considered when the value of La Roerie's ingenious proposal is assessed.

Unfortunately the archaeological material offers us little help. We do not in fact have any material at all which is relevant to the problems of steering. When we consider how long nautical tradition persists as well as the standstill in ship's carpentry during late antiquity, even Tursini's cautious proposal seems too daring. We may well doubt whether the apparatus ever advanced beyond the stage represented by the two elements of mounting: viz. the lashing round the leather-bound shaft and the strap fitted lower down to hoist the blade from its submerged position. Taking due account of the material at present at our disposal we are not entitled to advance beyond the arrangement constituted by these two elements, in spite of its inadequacy from the point of view of the practical seaman.

NOTES TO CHAPTER IV

1. Merab's tomb, seen as the funerary place of Chufu's son, (about 2500 BC) is generally dated to the IVth dynasty. The tomb has important ship-representations in low relief.
2. Early archaic (700-650) marks the border between the obscure ship-representations of geometric painting and those of proto-Attic with fine details of steering-oars. See Morrison and Williams: Plates Geom. 28, 42; Arch. 2, 16, 20.
3. Egyptian ship-building is extraordinarily well explained as early as the old Empire (IV and VX dynasties and timberships in Sakkarah). The records of Egyptian art are never more reliable than during the XVllth and XVIIIth dynasties: Queen Hatshepsut rock-cut tomb at Deir-el-Bahari, West of Thebes. The fine reliefs are interpreted by the French scholar J. Sottas in miniature moulds.
4. There are representative collections in the Cairo museum. Fine but limited collections are to be found in the Ny-Carlsberg Glyptothek, Copenhagen, and in the Egyptian galleries of the Vatican Museum.
5. Lepsius *Denkmäler aus Aegypten und Aethiopien* II Pl.2.
6. *L'Illustration* edit. Histoire de la Marine p.114.
7. Torr op. cit. p.2.
8. *L'Illustration* edit, Histoire de la Marine p.17.
9. See note 8 p. 18-19.
10. In Ny-Carlsberg Glyptothek Egyptian rooms
11. Köster op.cit. Fig. 7.
12. *Journal of Egyptian Archaeology* 33 plate VII. An interpretation of these paintings is given in *L'Illustration* edit. Histoire de la Marine p.21-23. Georges G. Toudouze: Phenicie (article).
13. Morrison and Williams Pl.14 C. and D. Attic black-figure sheds attributed to Exekias.
14. Münich, Antikensammlungen Nr.2049. Morrison and Williams Pl.13.
15. Vasepainters active around 510 BC. Morrison and Williams, p.106-8. Pl.18. Arch. 79-82.
16. Morrison and Williams pl.27 d. This Hellenistic relief, cut in live rock, is one of the major maritime documents of early antiquity, but relevant to oared vessels only.
17. Epistylion-element displayed in the porticoes along the Lechaion road close to the Roman baths. S. Kasas *Corinth and its environs etc.* Fig. 23. Plan by J. Travlos Nr. 34 (35).
18. L. Tursini, 'Note di Architectura Naval Romana di L.Tursini': Uccelli *op.cit.* p.369-393.
19. Uccelli *op.cit.* Fig. 357.
20. *Acts of the Apostles* 27, 40: 'After casting off the anchors and dropping them in the sea and meanwhile loosening the ropes that held the rudders they hoisted the foresail to the wind and made for the beach'.
21. Uccelli, *op.cit.* Figs 112, 223 (further reconstruction). A reconstruction of an oar fitted to an outrigger *(aposticchio).* Fig. 286: sketch of a reconstruction.
22. Uccelli *op.cit.* Fig. 187 shows the aft outrigger baulk of hull II with fitting applied. Fig. 15 shows a detail of this bronze fitting. Fig. 2 is a sketch of a reconstruction.
23. 'Navires et barques, figures sur des mosaiques decouvertes à Sousse et aux environs' Institut National d'Archéologie et Arts: Musée Alaoui: *Notes et Documents XV.*
24. Gauckler 'Un catalogue de la batellerie gréco-romain: La mosaique d'Althiburos': *Mon. Piot* XII (1905).
25. Duval 'Du Navire grec au navire romain' Melange Ch. Piccard: 338-351: *Revue Archéologique* (1949).
26. Carlini 'Le gouvernail dans l'antiquité' *Association Maritime et Aeronautique* (1935).
27. Lefebvre des Noettes 'De la marine antique a la marine moderne ou la révolution du gouvernail'.
28. Foucher frequently refers to Cdt. la Roerie's studies and articles without proper titles. These studies are not easily traced.
29. C. Torr "Triremes", a letter published in the *Classical Review* XIX 1905 p.466. Reprinted in *Ancient Ships.* Appendics p. 207.

CHAPTER V

Equipment, Ground-tackle and simple machines on board ship

Introduction

Every vessel, irrespective of its size and the area in which it is used, requires equipment for various purposes, in addition to the requirements of mere propulsion. Such purposes are: anchoring, mooring, handling of heavy objects and cargo, and the bailing or pumping out of bilge-water. The beaching of ships must also be considered, under special circumstances in early antiquity.

The light, oar-propelled, ship of war required a different set of equipment dictated by considerations of weight[1]. Spars and tools not absolutely necessary were left ashore when there was a prospect of naval action. It will not be possible to mention more than a few ship-board operations requiring equipment during the period here concerned and in particular those on board the sailing cargo-carrier. To determine the need for tackle, complicated hoists and simple machines, we may start this chapter with a survey of the actual requirements of muscular power. In this connection we need to consider the dimensions and displacement of the ships, their sail-area, the approximate weight of single spars etc., in relation to the crew carried. The need for power changed considerably. The situation in late antiquity was entirely different from that in the late archaic period or from that of the fifth century BC.

Power needed in the sailing cargo-carrier

The open, or partially decked, oared warship, practically a large boat accommodating a numerous crew (which represented a great deal of muscle power) did not require much equipment or simple machines. Every operation needed, including the beaching of the hull, was performed by sheer muscle-power directly applied. But in the case of heavier hulls, as affected by the pressure of wind and wave-motion greater than directly applied muscle power could master, the situation called for auxiliary arrangements and devices. Ground-tackle was developed, boats for shore-communication and towage were called for, simple machines were required for the handling of single pieces of cargo.

The propulsion of large hulls in estuaries or port-basins required power exceeding the direct muscle-power of deck-hands and called for simple machines: capstans or horizontal windlasses driven by muscle power. In the case of cargo-ships in particular, where the number of the crew was limited by various considerations, increasing dimensions and accordingly increasing displacement led to a number of practical difficulties: the *navis oneraria* was too heavy to be manoevred by oars either in the ship itself or in boats towing her; it was further estremely awkward to warp or to manoeuvre by means of clumsy ground-tackle. With the increase of dimension the size of single items of cargo also increased and necessitated the use of mechanical devices. Similar problems occurred in the working of the ship and the handling of sails. These latter are dealt with in the last chapter (VI).

Hull-weight and the corresponding need for power

The attempt to discover the relation between hull-size and the corresponding displacement, in spite of much serious research, is still difficult. We are sadly lacking in almost all details of actual dimensions and displacement figures. Some observations[2] based on modern experience may nevertheless be helpful. A man is able to handle and haul to windwards in a moderate breeze a hull of about 5 metric tons, while three or four men may in favourable conditions handle a coaster of 50-80 tons not using winches, but they lack the power to recover anchor in a light breeze when not using the windlass. A hull of 150-200 metric tons cannot be warped, hauled or towed by muscle power except in a complete calm and within a sheltered basin. Many difficulties arise when we try to adapt such practical data, derived from the experience of modern craft, to the hulls of antiquity, especially the sailing cargo-carrier, since the recording of its cargo-capacity or burden varies considerably.[3] Ancient authors gave the sizes, or alternatively the cargo-capacities, of ships; but lacked proper terms for such descriptions. There is unfortunately no representation in murals, mosaics etc., of a ship with a known capacity (in *modii* or *amphorae*). The limited material of ship representations referred to above cannot be analyzed as to main dimensions, which in their turn would give a key to carrying capacities. All figures indicating hull-weights or alternatively displacement, as well as supposed cargoes carried, suggested by modern scholars, should be looked on with suspicion or at least caution[4]. Nevertheless an attempt may be made, as follows, to determine the principal sizes.

Until the end of the 5th century BC the average cargo-ship corresponded to a modern (late 19th century) sailing coaster of about 50-80 metric tons. The displacement of Hellenistic ships may have been increased to double this figure, possibly more, reaching 100-150 metric tons. The carrying capacity of the heaviest imperial or late imperial carriers may in extreme cases by indicated by the obelisk-carriers[5], probably designed for a single mission. The maximum carrying capacity of the wheat ships of the Alexandria – Portus trade may, considering the facts given by Lucian in the *Navigium*, have amounted to 1200-1300 metric tons[6]. On the other hand there is reason to believe that the displacement of the average carrier employed under government contract did not exceed 400-500 metric tons. Torr suggests a modest standard size of about 250 tons[7], whereas 19th century scholars presented fanciful figures without regard to technical or nautical consequences. An incredible 3,500 tons being mentioned as a maximum[8].

Such categories are of secondary importance for our purpose, which is to determine in what circumstances ships were handled by direct muscular power and when mechanical aids, i.e. simple machines, were needed. Direct muscular power was probably not sufficient to handle the cargo-carrier of the archaic and early classical periods, since these ships were undermanned for the sake of economy. Only the oared warship carried a crew numerous enough to beach their ship so as to keep it dry and light, but this may apply only to oared ships of the archaic period which were partially decked and lightly built. For the opinions here given based on modern experience there is no evidence to be derived from literary sources of works of art.

The ship depicted in the 'Tomba della Nave' (Classic.1), of the early 5th century, represents a hull-category too heavy and bulky to be handled by direct muscular power. The displacement figure apparently reached a hundred tons, which called for labour-saving tackle etc. There is reason to believe that large cargo-ships from the late 5th century onwards were fitted with simple machines for the handling of ground-tackle, hoisting of yards, boats, and items of cargo. The method of cargo-handling is generally known. Food-stuffs, solid as well as liquid, were shipped in the ceramic *amphora*[9] of known standardised volume and weight. The gross weight of the loaded *amphora* corresponded to the handling capacity of an average man as *amphorae* were carried and stowed manually. The *amphora,* with a pointed base, was stacked in a vertical position, the lowest layer in sand. The stowing of *amphorae* in a ship's hold with upward curving floor and limited horizontal area must have called for method and skill. From ancient pictures[10] we know that *amphorae* were stacked upright and parallel to each other with a second layer on top fo the first, as underwater observation has verified[11]. Numerous Hellenistic and Roman wrecks show the special pattern of *amphorae* stowed above and between the lower layer in order to save space in holds very different from the prism-shaped cargo-spaces of 19th century sailing ships. Such stowage was a specialised task entrusted to guilds or trade unions known as a result of the excavation of terminals at Ostia and Portus which date from the 1st century AD[12]. Gerhard Kapitän reports on the method of stowing quarried stone as observed in underwater sites off the coast of Sicily[13]. Heavy timber, quarried stone for construction, sarcophagi, sculptures etc., were probably handled by specialised teams of guild members. Such operations required specialised gear: pulleys, tackle, derricks (cranes were used in construction), as well as simple windlasses mounted on shore or on deck.

For the handling of large items of cargo the dimensions of deck-hatches were of importance. Nothing however is known about hatches, nor of the method of closing and making fast deck-openings. The handling of heavy items below in the holds called for specialised teams of workers equipped with spokes and iron bars, levers and rollers etc. The handling of particularly large items such as entablements or sculpture, sections of columns, crated sculpture and obelisks required shore machinery too bulky to be carried on board ship. Such equipment probably belonged to the government organisation for public construction. These operations may have been carried out by slaves, but more probably by guilds of shore workers. As the shipping industry within the Empire was allowed to develop on the principles of free enterprise, ship-crews were kept at a sound minimum which would nevertheless assure the safety of the ship. The widespread organisation of the industry and the existence of numerous specialised guilds in the principal Mediterranean ports provides reason for believing that sailors were not employed in cargo-handling.

Removal of Bilgewater

The hulls of antiquity, whether propelled by oar or sail, were structurally underdimensioned, and by modern standards weak and of short life. Wrecks, the details and structural dimensions of which have been observed and recorded, show that the skeleton timbers have been subjected to heavy strain. The ship of antiquity, in particular at the time of the Roman Empire, was built with great care and regard for quality – at least as compared with modern wooden coasters of the Mediterranean – Nevertheless there is no doubt that these hulls leaked heavily. Under heavy strain in a seaway being of light construction they worked at the seams, so that the crew were occupied in bailing or pumping. There is no literary information on the techniques of this activity, but the Greek and Latin words are known for the bilge and bilgewater (Gr. *antlos, antlia:* Lat. *sentina*) and the bailer (*antétéria, sentinacula*[14]). The man who had the permanent responsibility for bailing *(sentinator)* was the lowest-ranking member of the crew.

Bailing by hand is possible in undecked or partially decked craft. The problem of how to remove water from decked oared vessels was never seriously faced, with the hull-space cluttered up with benches, oars, and oarsmen. In a decked vessel, especially when the bilge area was covered by cargo or ballast, bilge-water would have had to be raised by some mechanical device requiring a well or a shaft of watertight design.

The sail-propelled cargo-carrier, most probably decked in with a complete deck from the 5th century BC, was fitted with some kind of pump or water-raising device which we should regard as permanently rigged in the hold. These were of wooden design or of composite construction (wood and lead), like most ancient machinery, not very effective and heavy to work owing to friction. Although a considerable number of wrecks have been excavated no remains of wooden pumps of any kind have been observed. In the Nemi hulls however interesting fragments were to be seen which have been interpreted as parts of chain pumps of composite construction. As to actual pumps (chain- and piston- pumps) we refer to relevant sections of this chapter.

Anchors and anchoring

Many European scholars, from A.Jal[15] in the 1840's up to modern underwater archaeologists such as F.Dumas and Honor Frost (writing from the 1950's until recent years), have discussed the anchor of antiquity and its successive development. Frost[16] started a new direction by stressing the importance of 'rock-anchors' and 'sand-anchors' (flat pierced stones with inserted pointed pegs), which were used within the eastern basin of the Mediterranean and are similar to the Egyptian rock-anchor, frequently shown rigged ready for use. The purpose of the rock-anchor was to keep a ship steady in a chosen position, but against wind and sea no amount of stones would in fact be effective. When perfected the rock-anchor was of pyramidal shape pierced at the point by a hole for the hawser.

Such trimmed rock-anchors belonged to Greek oared ships but iron anchors were part of the regular equipment of Greek triremes[17], Frost discusses the function of the rock-anchor, improved by the attachment of crooked arms, from an ethnological point of view, and finds it widespread from the Atlantic coast of Europe to the Malayan Archipelago, from the Bronze Age to the present day. The rock-anchor is not however the appropriate equipment for the heavy sailing cargo-carrier, which requires an anchor able by dint of design and weight combined to grip the sea-bed, and appropriate cables for use in critical situations.

In spite of the interest which has been concentrated on the anchor proper and its development, the outlines are far from clear. According to Strabo a metal or iron anchor was designed by Anacharsis[18] about 600 BC, but no such anchors have been recovered from the sea-bed. Iron anchors are however recorded in the 4th century Athenian naval lists; and examples dating from the 1st century AD have been found[19]. Official lead weights from the Seleucid empire (Plate XXV) exhibit representations of fairly advanced anchors with metal stocks and shackles at the upper end of the shank and at the lower end at the crown (to enable a trip-line to be fixed). These odd-looking metal anchors should not be understood as symbols only but as real equipment of sea-going ships. (Plate XXVI).

The Composite Anchor

A great number of leaden parts or fittings[20] of ancient anchors have been recovered from underwater sites. A leaden stock has been found, cast to hold a squared timber, and a leaden tripartite fitting (or assembly piece)[21] with holes for squared timbers. No wooded elements have been seen. These two items were understood to belong to anchors, but the numerous reconstructions which have been made were rejected[22] until the excavation in Lake

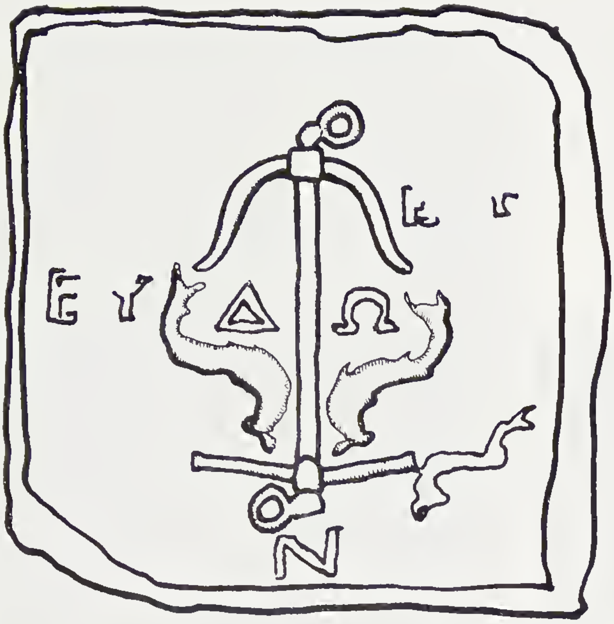

Plate XXV A seleucid official cast leaden weigth by Demetrius I. Soter. Abt. 150 B.C. from Rostowzeff, the Econ. history of the Hellenistic world.

This symbol shows a metal anchor with graceful flukes and a movable (?) metal stock. A ring is fitted to the crown for the important tripping line.

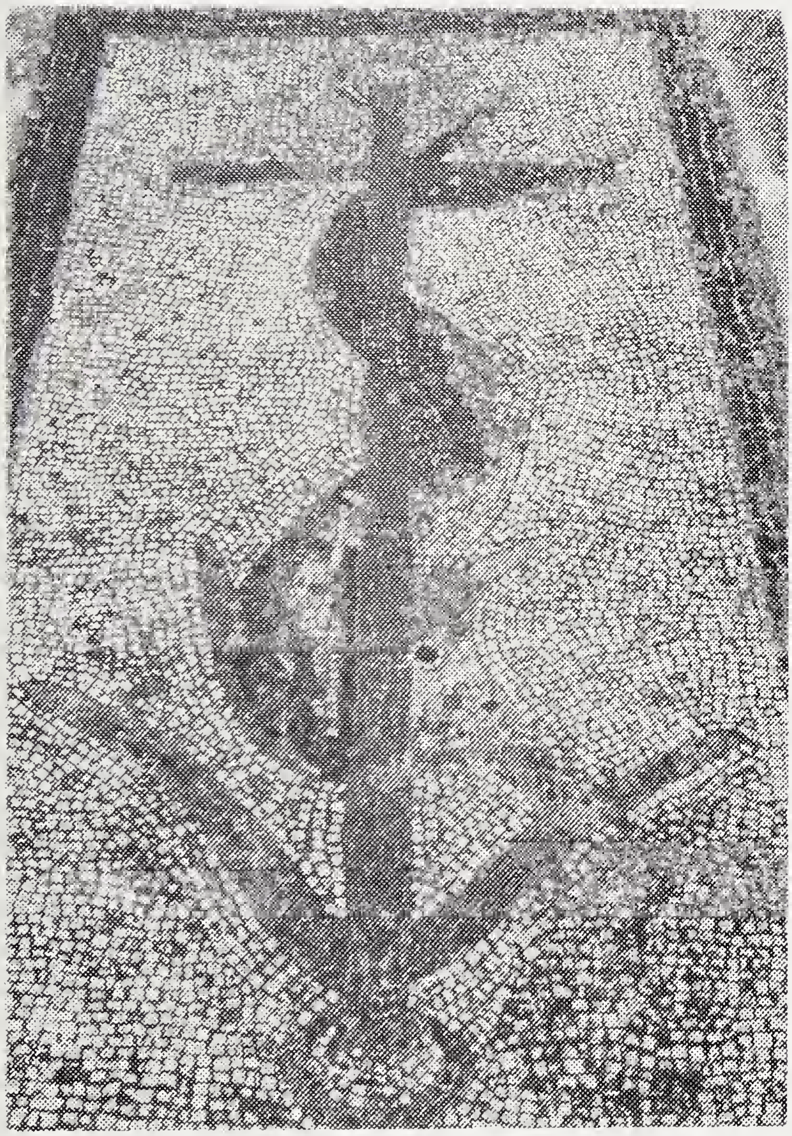

Plate XXVI A polychrome floor mosaic from the lavishly fitted Delian peristylion-houses from the 1st cent. B.C. The iron anchor with permanent stock is fitted with rings for the cable and for the tripping line, in 18th-19th cent. fashion.

Nemi was started. Here in 1930 a complete anchor was found dropped in the mud with hawser in position (Plate XXVII). The function of the leaden stock, i.e. to keep the shank down, was now explained. The Nemi anchor lacked the assembly piece, the place of which was taken in this case by heavy tenons passed through the three timbers and locked by wooden pegs. The pointed wooden arms were shod by metal flukes, like a primitive plough. The leaden stock is short by comparison with a modern anchor, too short to keep the anchor properly turned to dig into the sea-bed. The principle function of the leaden stock was to prevent the shank from rising from its horizontal position under the pull of the hawser and thus altering the angle and reducing holding power.

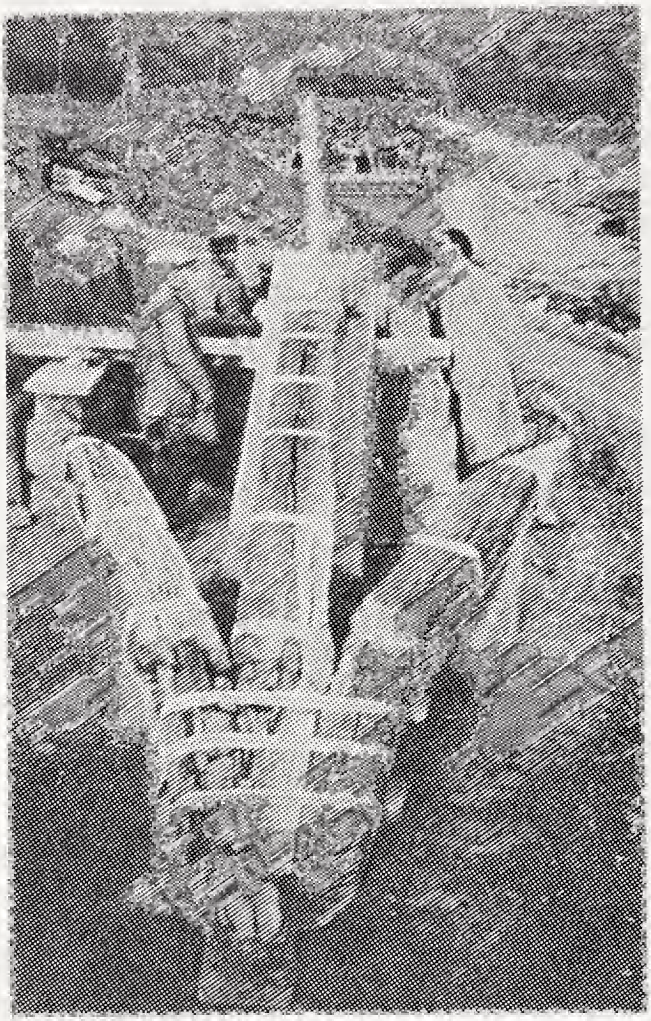

Plate XXVII The composite anchor from lake Nemi, found in situ. The anchor is composed from three timbers locked together by wooden trunnions. The flukes are shod by lead. The ballasting stock is cast in lead. Total length 5.5 meters.

Close to the wooden anchor in the mud of the lake was found a wrought-iron anchor with U-shaped arms of almost modern design with a detachable stock and a wrought-iron ring at the shank (Plate XXVIII). The anchor was properly seen as the ancestor of the 'Admiralty anchor' of 1851[23]. Here the archaeologists in charge of the Nemi operation stumbled on the fact that a similar anchor had been found in the Pompeii area[24] in 1857 but apparently had been forgotten. The iron anchor from Lake Nemi was sheathed in wood, the sheathing being kept in position by metal fittings and lashings. This odd arrangement was the cause of much discussion, since the wooden covering would have increased rusting. It appears that metal anchors as expensive equipment were given only to war-ships or state-craft, yet no Roman reliefs or official records attest metal anchors. For the light oared warship the bulky composite anchor must have been extremely unhandy.

Handling of Anchors

From the considerable number of lead fittings found under water it is reasonable to believe that composite anchors were standard equipment for sailing cargo-ships. The existence of numerous pairs of stocks and

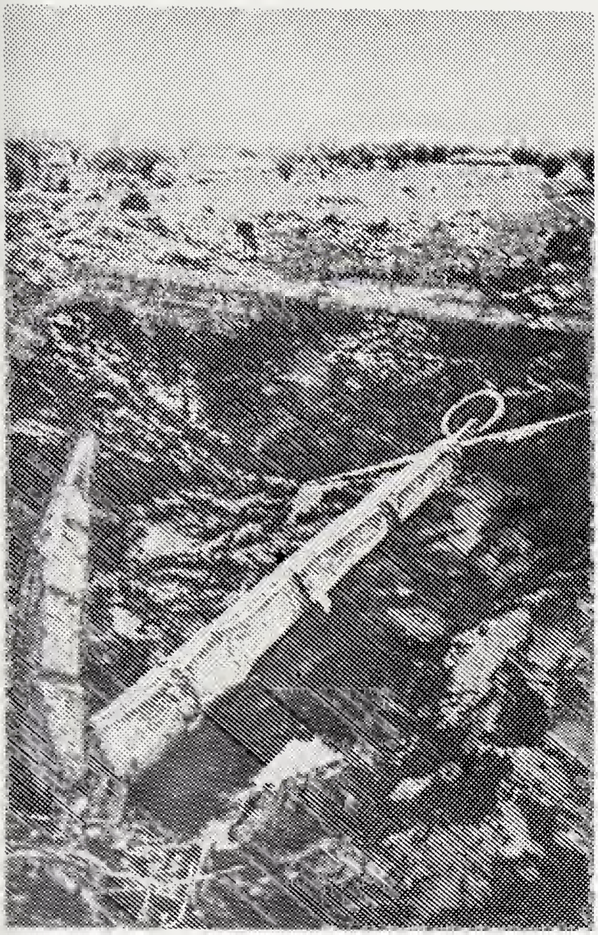

Plate XXVIII A wrougth iron anchor from lake Nemi, completely sheathed in wood. The iron stock is detachable. Weigth "1275 libbre" = 417 kilos. Total length abt. 4 meters. – A similar iron anchor was excavated in Pompeji in 1857.

assembly pieces recorded on a site of a single wreck suggests that ships carried many anchors. Notorious shoals and reefs have yielded great numbers of these lead fittings[25].

We learn from Athenaeus' incredible description of the mammoth ship 'Syracosia-Alexandris', built to the order of Hieron II around 260 BC by a Corinthian shipwright that this vessel carried eight iron anchors and four wooden (composite) ones[26]. It seems that this floating palace, as the king's maritime toy, was fitted out in a lavish way with supernumerary anchors. A line of anchors ending in a wreck[27] records the sad story of a sailing ship trying to avoid a dangerous shore by dropping and losing a succession of anchors until the moment of disaster. According to ancient tradition chains were introduced in the 4th century BC[28] The composite anchor was however laid by ropes or cables[29] which had a tendency to part by chafing. The reason for the many anchors lay thus in the weakness of the ropes or more accurately of the strap rove through the shank timber. This strap was unprotected and was later replaced by a ring or shackle. The use of chain close to the shank timber also remedied this weakness.

The composite anchor from Lake Nemi is of imposing dimensions. The exact weight is not specified, but it is clear that the handling of such a mass of timber would have required much power or mechanical aid. The dimensions of the Nemi anchor were determined by a very special purpose and it was probably never carried on deck. Leaden stocks however recovered from other places have similar dimensions and weights. The anchors to which these fittings belonged were certainly handled, dropped, weighed and hoisted. How were such things handled, and where was the necessary deck-space found for such unhandy equipment?

The holding power of the composite anchor was weak in relation to its size and weight. Hulls of modest dimensions were cluttered up with a variety of anchors for light and rough conditions. The leaden stock was apparently fixed permanently, and this added to the crew's labours, although a detachable stock is possible. Many deck-hands must have been required to move and drop anchor.

From the classical period at Athens the oared ship shows baulks protruding on each side of the bows at gunwale level (Gr. *epotides*), similar to catheads, the device for stowing anchors outboard in ships of the 17th to 19th centuries. These reinforced timbers protruding at about 45° at the bows are secured to the hulls and appear to have the function of battering rams at the level of the oars and outrigger. They are named catheads by British scholars in spite of the fact that anchors are never seen stowed from these baulks. But Euripides (*I.T.* 1350-1) describing the preparation of an oared ship for sea says: 'they hung the anchors from the *epotides*'. These baulks were apparently never fitted to sailing vessels, and a study of the representations of the *corbita* class of merchantmen shows that no arrangements for the handling, dropping or re-hoisting of anchors are visible. It must further be remembered that, although from mediaeval times onwards the fo'c'sle in European ships was the area housing ground-tackles and simple machines, it was not so in antiquity. A sea-going ship was unable to heave-to, turning instead the high protecting stern to wind and sea. In the nautically important record of Paul's voyage from Caesarea to Puteoli in an Alexandrian grain-carrier anchors were paid out from the stern to act as drifting anchors[31]. This may be considered as an emergency measure when the steering oars had been raised to prevent damage. In view of the high freeboard and buoyancy of the *corbita's* stern the placing of anchors and ground-tackle in general on the foredeck lacks a purpose. Unfortunately none of the representations listed offers information as to the permanent position of anchors, whether forward or aft, on deck or suspended outboard.

Hawsers, Bitts and Mooring Equipment

In representations of cargo-ships a number of mooring bitts are frequently visible above the rails and are emphasised by the artist. These are forward as well as aft, and there is reason to think that these heavy bitts served not only the purpose of mooring. Anchoring from the bow may have been the rule in ordinary sheltered conditions, since towing and warping was naturally practiced bow first. In a representation on an altar in the Museo Capitolino in Rome we can see the symbolical re-floating of the ship of the goddess Cybele which had grounded in the Tiber (Rom.2). This may be seen as an illustration of contemporary towage. The tow-rope is belayed on a heavy bit immediately inside the bow section on the side seen by the observer. Heavy hawsers have been paid out from this area of the ship (where they were probably stowed). Bitts of the same size are found also in the stern, fitted to the rails aft of the steering oars, and in addition also on the outrigged platform covering the steering-oars and their delicate bearings.

In spite of the popular opinion that the painted decoration of eyes in the bow acted as hawsepipes, we are unable to find such openings for hawsers in any ship representation. In connection with oared ships fairleads are mentioned. Their is reason to believe that mooring-hawsers, tow- and anchor-ropes were belayed to the bitts aforementioned placed to one side or the other of the centre line of the hull. This is not a disadvantage when the ship is moored or under towage in smooth conditions, but causes trouble when it is riding to a single anchor through the tendency of the hull to 'cut out'.

It is well known that a ship anchored in this way rides uncomfortably and turns her side to wind and sea. To avoid such consequence anchors were probably laid from both sides. When anchoring from the stern the broad cargo-carrier undoubtedly dropped anchor from both sides. Representations show the stern to have been broad and bulky compared to the fore-ship; the bitts in the stern were placed well outward of the centre line.

The representations give no clues to the method of storing, coiling or handling of ropes and hawers, nor to the way in which mooring to permanent shore installations was effected, although the excellent *Portus Augusti* relief shows two *corbitae* moored to stone-built wharves. The artist included the typical Roman mooring-ring, carved from a stone block and inserted vertically into the masonry, as observed during 19th century excavations on the left bank of the Tiber (with standardised late-Imperial wharves and sheds). Unfortunately the relief is broken where the rope from the mooring- ring reaches the ship.

Capstans and Windlasses

We have concluded that the heavy cargo-carrier of late antiquity would have needed simple power-saving machines – capstans and windlasses – to handle extra-large loads, her own yards and anchors.

The windlass is well-known from military technology[32]. Public construction (within the imperial administration) required a variety of machines for the hauling, hoisting or erecting of heavy items. In spite of the fact that the upright capstan and the horizontal windlass are mentioned in literature we are unable to observe either fitted to large-sized cargo-ships. On the other hand we observe the upright type of machine fitted to the deck of a coastal lighter (*navis codicaria*) being loaded with *amphorae* in a black-and-white floor mosaic at Ostia. A standing barrel is shown; with four horizontal spokes inserted, stepped on the raised poop-deck somewhat forward of the steering oars. This capstan apparently did not serve the ground-tackle, but the lowering and hoisting of the mast as dictated by the needs of river and canal traffic. A capstan in this position may be used for many purposes as shown by the Bremen 'cog' hull[33], in which a heavy capstan is placed on the raised deck aft. In the relief from Salerno cathedral (Rom.13) an object is to be seen which is to be understood as the standing barrel of a capstan without the turning spokes. The mast which has here been lowered forward and is apparently not stepped in a 'tabernacle' could not in theory be raised by this capstan, but this may be a lapse of the artist responsible. If a small-sized coaster carrying slip-up parcels of cargo exhibits machines for cargo-handling it is difficult to believe that the much heavier *corbita* was not equipped with similar mechanical aids.

In his admirable report on the wreck and material recovered from the underwater site of the Grand Congloue F. Benoit comments on some leaden objects, in particular a very special cast fitting covering a capstan and taking four horizontal spokes[34]. The design is functional to a degree and the purpose cannot be misjudged by anyone with a nautical eye. Nevertheless the use of a soft material for a deck-winch raises questions. The details of the fastening of this covering cap to the actual wooden barrel are unclear. The object was recovered from a wreck at Recif de Moyades, Ile de Riou, of a ship carrying *amphorae* which is not dated. The capstan to which the cap fitted may be compared to the standing manual winches for warps etc., fitted to 18th and 19th century sailing-ships, but it differs from these in lacking 'palls' which lock the movement and prevent rotation backwards. Without palls extra muscle-power would have been needed.

Lucian mentions the mammoth wheat-carrier 'Isis' diverted from her ordinary run in an emergency to Piraeus. He refers to windlasses and barrel-winches serving many purposes[35] but avoids nautical and technical details. We may conclude that a ship with a hull and rig of these dimensions would have been impossible to handle without labour-saving machines, at least in the handling of spars and sails. The Nemi hulls which yielded a rich store of information about imperial technology exhibit no simple machines or traces of such devices. But it must be admitted that in fact there was no need for them on board these stationary floating gardens.

Blocks for Rigging and Cargo-handling

The block fitted with a rotating sheave is late to appear in the nautical context in antiquity. There is reason to believe that the rotating sheave was used in military technology before being introduced into seagoing ships. Conservative tradition and technical backwardness apparently hampered the employment of circular sheaves rotating on wooden or metal pins in the rigging where they were required: e.g. to take the important halyards of the bulky mainyard which were frequently taken through bronze eyes which would have caused heavy friction and fast wear. Sheets and braces were single ropes. The clewlines were simple taken between the upper leach and the yard without eyes or cringles. At a later stage straps or leaden rings but not blocks were used. Attic red-figure vasepainting nowhere shows ships or rigs employing blocks of any kind. The earliest block used in rigging appears in the late Hellenistic period. The big cargo-carrier on the so-called Conteneau sarcophagus shows a single block in the main-braces, as well as an enlargement in the running tackles aft of the mast which may possibly be understood as a pulley fitted to the main-yard halyard and led to the stern-deck and not vertically.

The *corbitae* shown in the Portus relief (Rom.10) are fitted with single and double dead-eyes in the shrouds, not of course acting as blocks. To the artemon mast, which regularly carried the yard for the artemon sail, there is fitted a tackle with four parts, possibly for the handling of cargo. Why heavy items should be handled in this area cannot be explained. The mainyard halyards appear here to be repeated, one to starboard and one to port. In addition the mainyard is suspended by a pattern of topping lifts, apparently fixed, while it is possible that the halyards are led over rotating sheaves.

Among stray objects recovered from the Nemi hulls there is a large wooden single block[36] with a sheave 0.9 m in diameter rotating on a (corroded) pin. The housing was strengthened by an iron plate. There was no report of traces of cargo-block.

Reports from excavation at various sites (Port Vendres, Madrague de Giens, Cenchreai) mention wooden rigging-blocks (single and twin) with rotating sheaves. Similar objects have apparently been recovered from the County-Hall wreck. We have reason to believe that such friction-saving devices were common in seagoing ships with heavy rigs from the 1st and 2nd centuries BC onwards. We are still rather short of literary evidence for mechanical aids, cranes and other machines, used in construction, although there are some very informative casts and reconstructions in the Museo della Civilta Romana in Rome.

Bilge-pumps

Mechanical aids were employed to raise bilge water from the lowest level of the hold of the sailing cargo-ship. The height from the inner planking to the main deck is not known, but may be estimated. To the considerable breadth of these ships there corresponded medium freeboard and draught as the cargo-ship retained its general flat barge-like shape (round ship). At the end of the 19th century a wooden cargo-ship of 500-800 metric tons deadweight capacity had a corresponding height of ten feet in the hold. Lucian describes the wheat-carrier 'Isis' as being 120 cubits in length overall (180 ft), with a breadth more than one quarter of this (i.e. at least 45 ft), while the height from keel to deck was 29 cubits (43½ft). This last dimension (about 13 metres) represents a water column in the pump-shaft of extreme height and weight. The information is nevertheless logical and credible, being probably derived from the ship's officers.

Chain-pumps

Machines designed to raise water in late antiquity are described by Vitruvius[37], but the author is concerned with irrigation where the column of water is low. Of the types described only the chain-pump, the *sentinaculum,* was suitable when very high columns of water were involved. Plunger pumps fitted with valves, as described by Ctesibius, are also mentioned by Vitruvius, but the text lacks logic and the fitting of the valves is unintelligible. The text may have been corrupted in medieval times, or Vitruvius may have understood Ctesibius wrongly[38].

Among the miscellaneous objects from Lake Nemi there is also a teethed wooden wheel fitted to a shaft as well as the necessary bushings or bearings[39]. These fragments are seen as part of the working set of wheels operating the endless chain of a *sentinaculum* driven by hand. Both hulls showed pump-shafts of square section passing through the inner planking where one frame was cut to allow the shaft to reach the outer planking. Most probably the wooden shaft containing the chain-pump was placed in this aperture[40] which was too big for a wooden plunger-pump of reasonable design. Bailing by means of buckets must be considered out of the question. The fragments recovered are small and the reconstruction hypothetical.

Plunger pumps

The Nemi hulls yielded some cylindrical wooden objects identified as plungers for a horizontal pump[41]. The plungers here act as valves (like a modern ball-valve) being pierced vertically to house a movable cylindrical object which opens or closes the passage of water. It closes when the plunger moves upwards and opens when the plunger moves downwards ('suction and lift' principle). Of the actual housing nothing remains. A theoretical reconstruction[42] shows a solid log bored to act as a cylinder without a bottom valve. The plunger is fitted to a metal bar which acts as a lift. Movement is strictly limited owing to the internal valve functions. This reconstruction is simple and credible but refers to a more primitive variety of pump than that attributed to the Nemi hulls, i.e. to the 'fisherman's pump' with a leather bag tied to the plunger[43]. This basic pump must have existed in the early Mediterranean world.

During excavations in and around Rome, as well as in Roman Britain (Silchester) Roman Gaul (St. Malo) and Roman Belgica (Trier), pumps have been recovered and partly published. The respective locations suggest water supply. These pumps represent a composite construction with wooden housing and with flap valves fitted in metal bushings sunk in the wood. The principle is 'suction and pressure' a technical advance from the 'suction and left' principle. The combination of wood and metal is of special interest in as much ad lead, cast or hammered, was used throughout in shipbuilding. Roman piston-pumps, according to the principles described by Ctesibius and by Hero (c.60 AD), machined in bronze and representing a high-level of technology have been found and properly published (the 'Madrid' pump form Sotiel Coromada, two from Bolsena now in the British Museum, the 'Civita Vecchia' pump (now lost), and four identical pumps from a Roman wreck west of Cannes (St Raphael) excavated from 1972 onwards).

On the sailing ship machines, tools etc. were no doubt of wood, using the omnipresent leed for fittings. It is probable that the cargo carrier of late antiquity was equipped with a simple plunger pump, made of timber and with leather flap valves, as occurs in 17th and 18th century coasters and fishing craft. Adzed and bored from a trunk this pump was strong enough to be left standing in the cargo without a supporting plank-shaft and resting on the inner planking. More advanced pumps of composite technique may have existed in ships, but since intricate internal valves not easily accessible ran the risk of blockage pumps of simple action, which are easily cleaned, are more likely in cargo-carrying hulls.

The simple 'fisherman's pump is properly worked in a standing position with a vertical plunger bar continuing upwards: its operation is tiring. With greater volumes of water and a high column constantly motivated the labour is too great. The task is made easier by the fitting of a pivoted horizontal lever operating the vertical plunger. This principle, as seen applied in village wells, is very simple and became widespread in medieval times, ashore as well as afloat.

We now have evidence for metal pumps of cast construction being used in seagoing ships contrary to previous opinions that ancient pumps were used only in fire-fighting (Vitruvius 10 7); to such a category belong the 'Madrid' pumps and the lost pump from Civita Vecchia, both commented on by Thorkild Schiöler in his *History of Technology*[46].

In the Roman wreck called 'Dramont D' close to St Raphael which was excavated from 1972 onward four bronze pumps of identical design were found. They were published by George Rouanet in 1974[47] The pumps of 'suction and pressure' principle were of cast construction and box-shaped with a vertically operated piston and hinged flap-valves. These pumps apparently belonged to the permanent equipment of the ship since they were fitted to pipes which effected the display of bilge-water. All the pumps were found together which suggests a central 'pump-station' in the lowest area of the hold. They were, most probably operated from a higher (deck) level, since, owing to the simple functioning of their two valves each. They would not have easily become blocked, and were therefore suited to a position below the cargo. Rouanet's excellent study with its unusually clear illustrations changes the picture of bilge-pumps in the period of advanced Roman technology as applied to irrigation, public water-supply, mining and seagoing ships. In this respect recent underwater archaeological discovery has added to the technical knowledge supplied by the Nemi hulls.

NOTES TO CHAPTER V

1. Since the principal planned characteristic of the oared ship in the classical period was speed over short distances, weight was reduced by all possible means. Equipment both of the ship and of the crew was strictly limited. When a battle was in prospect the main rigging was taken ashore. Thucydides VIII 24, Aristophanes *Lysistrata* 61-4.
2. From the author's personal observation in the 1930's-1950's in the Baltic, mainly of Swedish-Finnish coastal traffic.
3. The capacity of the cargo-ship was given in talents (@ 26.19 kilos) or alternatively in *amphorae* (@ 26.19 litres), both representing one cubic foot (Greco-Roman). The big carriers of late antiquity were described as loading e.g. ten-thousand talents (about 250 tons) or 2000/3000 *amphorae*: Pliny VI 24. In the wheat trade the Greek measure, the *medimnos*, was used, which was equivalent to 2 cubic ft = 58.9 litres or alternatively the Roman *modius* = 8.75 litres. The *keramia* (= 25.9 litres) was also used. Köster *op.cit.* p.27; Torr *op.cit.* notes 71, 72.
4. The 'tonnage' roughly estimated by modern authors is usually based on hap-hazard references in classical writers who are unaquainted with nautical terminology. Typical of such estimates are all the data concerning Hiero II's mammoth ship (built about 230 BC) described by Athenaeus in the 3rd century AD on the basis of accounts by Moschion and Callixenos (of the 3rd century BC). The dimensions of the Isis, described by Lucian (*Navigium* 5) were given in Egyptian cubits. From the concise main dimensions the Isis's carrying capacity was estimated by various (19th century European) authors as follows: Jal 1500 tons, Graser 1575 tons, Breusing 2672 tons, Assmann 2000 tons, Köster 3000-3500 tons. According to the simple rules of Thames measurement Casson calculates her tonnage as 1,220 tons. Casson The Isis and her Voyage: see bibliography.
5. Torr *op.cit.* p.26-29: Köster *op.cit.* p.162-165, Persson *op.cit.* p.151-2.
6. Casson 'The Isis and her Voyage' p.55-56.
7. Torr *op.cit.* p.25.
8. See note 4.
9. The average gross weight of the loaded *amphora* is calculated by Benoit (*op.cit.* p.163-4) as 34-36 kilos.
10. Casson *The Ancient Mariners* Pl.9 b (a floor mosaic from Tebessa 2nd Century AD).
11. Benoit *op.cit.* 'Mode de chargement', p.164-8, Figs. 87, 87b is 88, 89.
12. Meiggs *op.cit.* The Guilds p.311-318. Casson 'Harbour and River Boats of Ancient Rome' Pl. II (3).
13. Kapitän, various observations in *Archivio Storico Siracuzano, Sicilie Archaeologia, Archaeology and I.J.N.A.*
14. Torr, p.61, note 139 where he collects the relevant references.
15. A.Jal *Archeologie Navale*
16. Frost *op.cit.* Part II 'Anchors and Anchorages' p.34-41, 42-61.
17. Frost *op.cit.* Part *n*, Ch.4, p.48-51 who refers to Isidore
18. Strabo VIII 3 9
19. A wrought-iron anchor found in Pompeii, Uccelli Fig. 272. Anchors fitted with a detachable stock: a cast from a concretion recovered from La Ciotat (French Riviera) Frost *op.cit.* p.60. A wrought-iron anchor with detachable stock, sheathed in wood, recovered from Lake Nemi, Uccelli *op.cit.* Fig.270.
20. Leaden items, primarily stocks, are recovered by Greek and Turkish sponge-divers within the Aegean and along the African shoreline. By systematic search on well-known shoals in S. Italy leaden items (indicating lost anchors) have been found along a line marking a ship's track from the dropping of the first anchor until the actual stranding.
21. This fitting held together three timbers meeting at pointed angles. For the function of the 'collar' or connecting piece see Kapitän *Archaeology* 24 Jan. 1971 p.52-3. This 'collar' was probably cast in sand raised around the three timbers assembled in a standing position.
22. F. Moll: 'Ein Bleianker' *Archäologischer Anzeiger* (see Bibliography). Moll's theory was ruined by a Pompeian floor-mosaic in the Casa dei Ancora (Uccelli op.cit. Fig. 279), and by the intact composite anchor from L. Nemi. See also Gerhard Kapitän 'New Evidence of Ancient Anchors' *Archaeology* 24 Jan 1971.
23. Uccelli *op.cit.* p.235-238, Figs. 269, 270.
24. Uccelli *op.cit.* Fig. 272.
25. In the Museo Nazionale Palermo, there is a considerable number of leaden anchor parts from a limited shoal NW of the port.
26. Persson *op.cit.* p.144.
27. Throckmorton reports on work carried out at Torre Sgaratta (Taranto) in a stencilled paper.
28. Herodotus IX 74, Arrian *Anabasis* II 21, Caesar *De Bello Gallico* III 13.

29. Uccelli *op.cit.* Fig. 268 (a sketch of the anchor *in situ*) Fig. 278 (a reconstruction) shows the method of tying a hawser to a composite anchor by laying a loop round the leaden stock and seizing the hawser to the wooden shank.
30. Morrison and Williams *op.cit.*Pl.26 c. A rhyton of Apulian manufacture shaped like the bow of an oared warship in which the *epotides* on each side form the bases of the looped handles of the drinking-cup.
31. *Acts of the Apostles* Ch.27.
32. Diels *Die Antike Technik. Sieben Vorträge:* Die Antike Artillerie p.96-100
33. Fliedner, Siegfried *Die Bremer Kogge,* Figs 14, 15.
34. Benoit *op.cit.* Fig. 101, 101 bis (Moyen de cabestan en plomb)
35. Lucian The Ship of the Wishes IV 435. Samippus speaking: 'anchors in front of them and capstans and windlasses and the cabins on the poop'.
36. Uccelli *op.cit.* Fig. 179.
37. Vitruvius On Architecture IV 1-4, VI 1-3, VII 1-4.
38. The language of this MS, dated to the 8th century, is said to be Latin of the market and the shop.
39. Uccelli *op.cit.* Fig. 198,199. Fragments of a reconstruction of a *'sentinaculum.*
40. Uccelli *op.cit.* Fig. 201, 202. a well for the pump-shaft.
41. Uccelli *op.cit.* Fig. 200
42. See note 41.
43. The simple plunger-pump with the leather bag is known in the 14th and 15th centuries and used in fully decked hulls in northern waters.
44. Uccelli *op.cit.* Figs. 216, 217.
45. Greek and Roman Life (British Museum) Pumping Machinery II. Uccelli *op.cit.* Fig. 215.
46. Schiöler, Thorkild: 'Bronze Roman Piston-pumps' *History of Technology* 5 p. 17-37 (1980).
47. Rouanet, Georges: 'Étude de quatre pompes à eau romaines provenant de l'épave Dramont D'. *Cahiers d'Archéologie sub-aquatique.* Numero III (1974).

CHAPTER VI

Rigging and Sails of the Cargo-Carrier

On the Development of Sails in Early Antiquity

The permanent rigging of the sail-propelled cargo-carrier evolved in stages from the light auxiliary rigging of the boat or ship of the Bronze Age. This simple rigging with a single mast and one or two yards we find on Minoan seals from the mid-second millennium BC. We have reason to believe in the existence of the broad square-sail with two yards, as later used by the Egyptians, within the Minoan area. This broad (oblong) sail is depicted on a pyxis from Pylos belonging to the late Mycenaeon period. After the Minoan collapse we find a merging of the Egyptian and Phoenician nautical traditions in the eastern corner of the Mediterranean. From this derives the seagoing trader for long-distance navigation propelled mainly by sail. The evidence for parallel sea-going craft within the Aegean and the former Minoan sphere in the 'Dark Age' and the Geometric period is very slight. Mainly from tradition reflected in poetry but also on slight archaeological testimony the Phoenicians are sometimes considered to have been the mercantile and nautical tutors of the Greeks of the 'Dark Age' and the Geometric period.

The broad rectangular sail was still carried in Egyptian fashion lashed to an upper yard but also fixed to a lower yard, supported by a great amount of running rigging which acts as a pattern of topping lifts. This easily controlled sail, effectively prevented from bellying, and from becoming unmanageable when taken back appears to have been efficient in most conditions.

The rigging of coastal craft in Geometric Greece and the Aegean is described in various sequences in the Odyssey[3] i.e. the light auxiliary single-minded rig of the partially decked oared boat or ship. The mast is sturdy and self-staying, stepped into the *mesodine* probably a kind of box or tabernacle. For security, simple shrouds are belayed at points fore and aft, or obliquely on each side of the bow and stern timbers. Ropes were cut from hides for standing as well as running rigging. The single sail was lashed to the yard which was hoisted to its working position. Sheets, braces, buntlines and reef-tackle are not mentioned in texts.

This type of rigging is depicted systematically in the late Bronze Age[4], on the other hand the abundant pictorial material from the Geometric period especially from the late Geometric (750-670 BC) contains only a few representations of oared ships under sail. There is a short pole-mast, supported athwartship and carrying a single yard for the rectangular sail, still very broad. Sheets and braces are depicted. We may study this rig in Greek shipping of the early Archaic period (650-600 BC) from the oblong ivory relief found in the temple of Artemis Orthia in Sparta (National Museum: Athens Inv. No. 15362): Plate XXIX). Here the very short pole mast is heavily supported in all directions, the yard is permanently hoisted to its working position with the sail brailed up. The length of the yard seems exaggerated in view of the length of the waterline. A similar hull and rigging is to be seen on an Attic cup in black-figure technique from the late Archaic period (550-530 BC) by Exekias[5] depicting Dionysus crossing the sea. Here we find sheets, braces (doubled and rove through a block), clewlines taken over the yard (three in each half, as well as the lashing of the yard in detail. We can further observe the (bronze) cap at the top of the mast with two eyes, through one of which the hoist is taken 'dry' (i.e. without rotating sleeves). The mast is apparently reinforced by seizing, the purpose of which remains obscure since the mast is not made up of several timbers. From an Attic blackfigure sherd of about 550 BC (Nat. Mus. Athens Inv. No. uncertain, Plate XXX) we are able to note the almost 19th century method of sewing a cringle to the lower corner of the sail to take the sheet. Further details of contemporary rigging are to be found in an early red-figure Attic stamnos (520-480 BC) depicting Odysseus and the Sirens and showing an oared ship with raised mast and mainsail brailed up (BM E 480). There are braces and a total of eight buntlines apparently taken over the yard and led aft to cleats in front of the helmsman. The artist shows the mast-head cap with two eyes in detail, probably cast in bronze. The use of two parallel hoists or halyards is

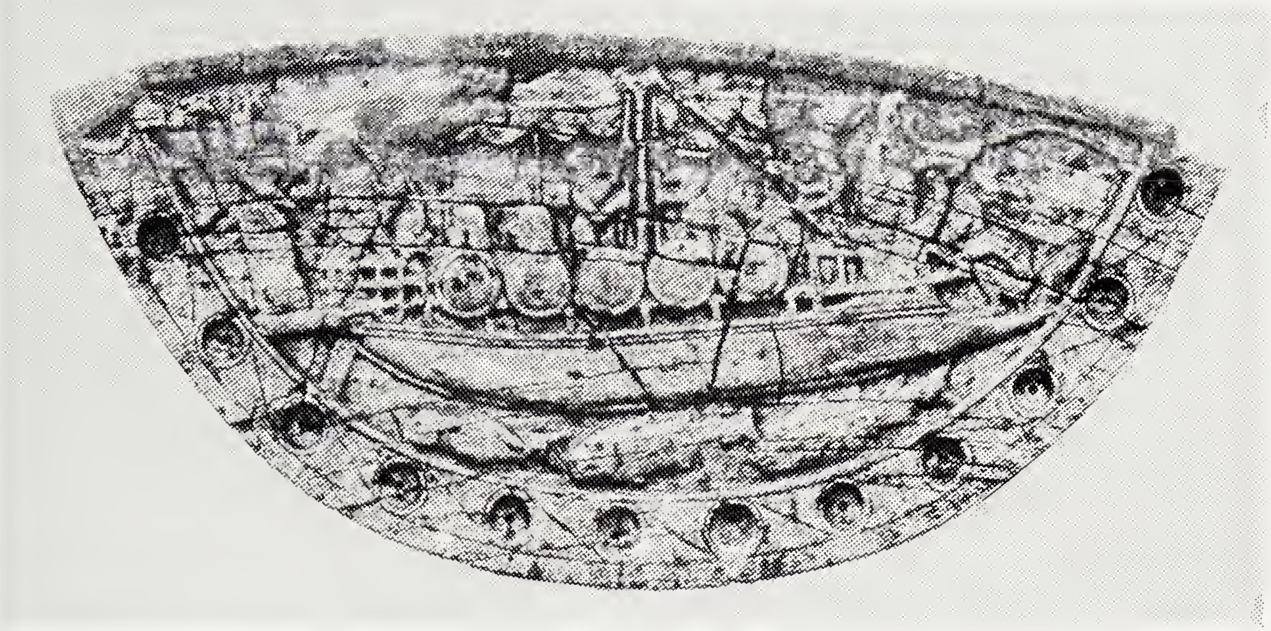

Plate XXIX Carved ivory relief from the temple of Arthemis Orthia, Sparta. The National Museum, Athens. A light oared warship tied stern to shore. Hoplite-warriors on deck; various activity on the foredeck and ram. The long yard with the sail brailed is hoisted to a short polemast, showing a complex fitting to take standing and running rigging at the head.

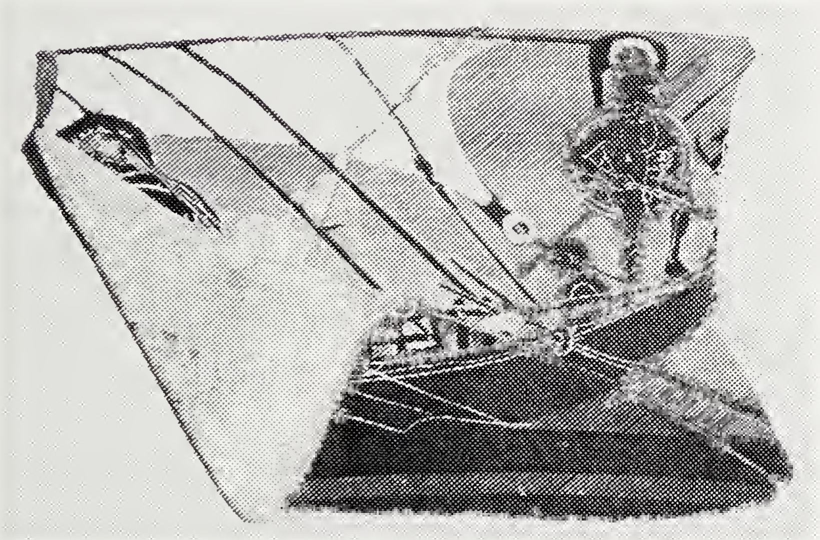

Plate XXX A sherd of blackfigured attic ware, abt 550 B.C. The National Museum, Athens.

A light oared ship under sail and oars. The helmsman handles the steering oars which apparently lack tillers. The sail ends in a ring which takes the sheet. The black area may represent a seizing forming a cringle in the roping of the leech.

here confirmed; apparently the yard lacked the fixing strap (corresponding to the 'rack') securing it to the standing spar.

The sail-propelled cargo-ship

A black-figure kylix in the British Museum provides the earliest representation of the rig of a Greek cargo-ship. It still corresponds in most respects to the rig of the oared ship. The extremely lucid representation (given twice once on each side of the cup) leaves us in doubt only as to the method of supporting the mast towards the stern and as to how the buntlines were belayed in front of the helmsman. The mast shown is apparently pemantly stepped and the existence of double stays aft may perhaps be assumed. A total of six buntlines appear to be belayed separately at six different points. The sail is shown as pulling while half brailed as indicated by the vertical parallel lines in the canvas close to the buntlines. Lacking further material from the 6th century we have to rely this representation only for the sail-propelled Greek cargo-ship of the late Archaic period.

It is a strange fact that there are no surviving representations of Greek cargo-ships from the classical and early Hellenistic period (5th and 4th centuries B.C.)

This has caused scholars to believe that the coastal cargo ship of the Greek world remained basically unaltered, though with increase in size for two or three centuries. From military sources we are aware of a brisk naval and military development during the heyday of the Hellenistic kingdoms, although these facts are not confirmed by archaeology. At the very end of this period (2nd and 1st centuries B.C.) seagoing merchantmen of considerable size certainly existed, but contemporary representations are exceedingly scarce. These ships were apparently not inferior in tonnage to the long-haul carriers of the early Roman Empire. Government-controlled trading had its beginning in the commissioning of the fleets of Syrian and Egyptian merchants. It is reasonable to envisage a continuous yet careful development of shipping irrespective of ship sizes during the whole period of Hellenistic economic expansion.

The Two-Masted Rig of the Cargo Ship

Until the unexpected publication of the ship painting in the 'Tomba della Nave' within the grave area of Tarquinia, dated to the fifth century BC, scholars believed that cargo ships of this period carried only a single mast. The new evidence for a large cargo ship with two masts brought a change. The mural, dated to 450-440 BC is certainly painted for an Etruscan client, but the artist himself may have been Greek, either from the inland or from the east?

The ship should therefore not be seen as solely belonging to the Etruscan sphere but as a universal type representing shipbuilding and nautical practice of the 5th century when the whole Mediterranean was opened up for trading. In spite of Etruscan maritime activity there is no reason to believe in any outstanding original Etruscan ship-building or nautical development. The mural should be understood as a representation of international achievement within the eastern basin of the Mediterranean.

Since there is reason to assume that Mediterranean shipping and shipbuilding was merged into an international nautical tradition covering steering, rigs, sails etc., already in the 5th century, the two-masted carrier depicted in the Tomba della Nave may be seen as the crack cargo-liner of her age. Greek, Phoenician and Carthaginian ships undoubtedly called at Etruscan ports and may indeed have been winter-bound there, so that the ship was beached in accordance with Mediterranean custom still practised by coasters and seagoing fishermen in Italian seaports. In the mural the ship is shown complete with the hull, which would have been submerged, yet under full sail.

The mural as it is presently restored – and further reconstructed in Moretti's fine plates – shows a lack of understanding of how the ship would have been worked. The main rigging is shown stepped amidships and supported as usual, but the second mast, of apparently almost similar dimensions, is stepped in an almost vertical point as far out in the narrow bow. For technical reasons it would be difficult to mount in a position of such structural weakness a spar which could carry a sail. The square-sail shown is out of proportion to the yard hoisted and to the heavy, tall, mast. The artist appears to have observed a two-masted ship equipped with the ordinary main-rigging but also with a small square-sail on a spar placed far in the bow. Such a fore-rig would be the same as the auxiliary rig called *akateion* in the oared warship of the 5th century BC which was stepped at an angle of about 45° to the surface of the water. This auxiliary rig was later adopted as a permanent arrangement in the cargo-carriers of the Hellenistic and Imperial periods. As shown by the artist of the mural, the smaller sail is totally overlapped and lacks a purpose in whatever direction the wind is blowing. If inclined forward the mast lowers the sail into a position where it can catch the wind. In this position this auxiliary sail is of importance when running before the wind, as well as in manoeuvring. Technically an inclined foremast may well be stepped out in the bow. A heavy spar, on the other hand, stepped vertically in the same position would cause severe difficulty, i.e. heavy strains in timbers above the keel and floortimbers.

Standing and running rigging is roughly indicated (as restored) and, like the sail-plan as a whole, is not reliable. There are however details of considerable interest. In the fore- and aft- supports of the main-mast we observe double stays running aft, apparently secured to strong-points to starboard and port. A single stay runs forward. The difficult supports of the fore-mast have been omitted by the artist. Braces are not shown where they are to be expected, but there is a mainbrace in a peculiar position inboard of the end of the yardarm. The sails are depicted in the manner of the Attic vase-painters. The aft surface of the sail is shown plain without seams, while the forward surface, visible where the canvas curves in front of the standing leach, shows horizontal seams starting from cringles in the leach. There is a complicated system of clewlines for both sails, eighteen for the main-, seventeen for the artemon-sail. These clewlines are apparently simply taken between the yard and the horizontal leach without cringles etc, and belayed haphazardly at deck-level to a great number of cleats.

The rigging as shown, heavily restored, is difficult to interpret. Painters executing ship-portraits relied on certain conventions and tricks in the representation of sails, which were adopted by non-Greek artists. A brisk discussion has arisen concerning the ship in the Tomba della Nave. Whatever the final interpretation of the artist's aim and purpose may be, this extraordinary portrait of a ship is proof of the existence of a more complicated compound rigging in seagoing cargo-ships. Two-masted rigging (main mast and *akateion* or *artemon,* sometimes used separately) was standard on oared fighting ships from the end of the 5th century. It was successively developed during the 4th century and the period of the Hellenistic monarchies. The Phoenician seagoing cargo-ship shown in relief on the so called Conteneau sarcophagus, dated to the 1st century BC, should be regarded as the product of three centuries of undisturbed nautical development.

Thus the publication of the funeral murals in Tarquinia by Moretti brought about a complete change in previous conceptions: a sea-going cargo-ship of ample dimensions existed at the time of Pericles, possibly even earlier.

Development in the Late Hellenistic Period

The Syro-Phoenician ship depicted on the sarcophague from Sidon is of interest from many points of view, since it corresponds to the Egypto-Roman wheat-carrier of the 1st century AD. As far as the rigging is concerned the type of late antiquity is already developed with a heavy mast inclined slightly forward and carrying a single, almost square, sail. The *artemon*-mast carried is more upright then the auxiliary spars of oared ships. This additional rigging is an important complement to the main rigging, making steering easier when running before the wind, as well as in wearing off when heading into the wind. With the single broad and low square-sail only very simple manoeuvres were possible. The hull would have reacted to the steering oar only when the ship was under way. Manoeuvring in a cramped space would have required the use of some heavy oars, 'sweeps', handled by many hands.

In the ship on the Conteneau sarcophagus we find a sturdy hull with high freeboard and equipped with a well developed rig exhibiting many details. Although some improvements were made during the four centuries of late antiquity, the Conteneau ship displays the already almost standardised rig of the Empire. Since there is a dearth of literary sources to provide evidence to complement this single work of art from Hellenised Sidon, it must be regarded as representing the sum of our knowledge of nautical development during the three Hellenistic centuries. It has not been recognised as such by scholars, who have frequently cited and taken seriously dubious literary texts e.g. the accounts of Moschion quoted by Athenaeus of Hiero II's mammoth ship, the 'Syracosia', later named 'Alexandris',[8] built by the Corinthian shipwright Archias. The description of this monster 'requiring as much timber as sixty oared ships' is nothing more than a list of luxury accommodation above and below deck. Moschion gave no description of the actual character of the ship, of its cargo capacity or loaded depth, except that the ship was too big for all existing ports. Unfortunately nothing is known about the movement or manoeuvring of this leviathan'. The construction of this parallel to the 'Great Eastern' appears to have been the result of some whim of the ruler of Syracus. According to Athenaeus the ship reached Alexandria where it remained beached having been abandoned as too big for the first class basins of Ptolemaic Alexandria. Typical of the writers of late antiquity are a variety of haphazard details and anecdotes lacking any substantial importance from a nautical viewpoint. Men of letters paid no attention to ordinary sea-faring matters or to the basic operations of contemporary economic life. Athenaeus did not mention the rig of the 'Syracosia', remarking only that the masts were used for military purposes.

The ship of the Conteneau sarcophagus shows a variety of hull-details, but unfortunately equal attention was not paid to details of the rigging. We observe again the heavy doubled back-stays to take the strains of running' in heavy seas with a hull deeply laden. Only a single shroud is actually visible uncovered by the sail on each side, but there must have been a number of such stays. A forestay is visible but set behind the mainstay (possibly to emphasise its importance). The *artemon*-mast is shown without any shrouds or stays whatsoever. The mainyard, in two halves lashed together, is a spar of imposing dimensions. The (starboard) mainbrace shows a single block at the yardarm, indicating a pulley which the considerable strain of the working sail area would have made necessary. There is reason to think that the topping-lifts were doubled with single blocks at the yardarms. Aft of the mainmast a detail may be observed which may be interpreted as a complex tackle for the mainyard halyard or hoist. The mainsail shows vertical and horizontal seams in a chequered pattern, as well as heavy leaches. Clewlines are for some reason omitted by the artist, and the arrangement of the mainsheets is obscure. The French archaeologist, J. Sottas[9], made a model of the Conteneau ship stressing the nautical aspects of the relief.

There are no other representations of cargo-ships from the Hellenistic period, but similar details are to be found in material from the Empire (see the inventory list in Chapter II) which shows little development until the time of Constantine, except in general dimensions and the consequent need for power in handling. The basic features remain constant: a heavy mast carrying an *artemon*-mast stepped at an angle of about 45° carrying a sail of increasing dimensions. The size of ropes for shrouds and stays also increased, and the devices for setting up the standing rigging improved. This rig enabled ships to sail with the wind on the beam possibly to point a little to windward (seven points from the wind ?). The principle of tacking was not known in antiquity. Opinions about the ability of ancient sailing ships to work to windward differ considerably.

The Uniform Rigging of the Empire

In the previous section we have summed up development during early antiquity and traced a fairly standardised rig employed within the eastern basin of the Mediterranean. Information is lacking about the western basis. The Augustan economic system, in which the grand scheme of grain shipments to Rome was an important part, called for seagoing tonnage in large sized units. The great carrier of the Empire, the *corbita,* maintained a rig practically unchanged during the four centuries of late antiquity. Although our sources of information are deficient we are bound to believe that the great carrier was basically unchanged when the direction of the grain-trade changed, setting towards the new capital on the Bosphorus about 330 AD. The wheat-trade into Ostia and Portus did not however collapse entirely, but continued during the 5th century until the turbulent conditions in the Mediterranean area put a stop to regular trading in the central basin. When Egypt was occupied by the Arabs in 670 AD the supply of corn from this area to the Byzantine empire came to a stop. From the evidence of some late coins it is reasonable to believe that the type of carrier which had been developed in the heyday of the Empire continued to exist with the same basic feature unaffected by technical improvements. The late appearance of the lateen sail will be discussed at the end of this section.

We must now consider the size of the hull in relation to the dimensions and handling of sails. By the first century AD mammoth ships[10] were being built on the pattern of the ordinary cargo-ships. The wheat-carrier 'Isis' (2nd century AD) described by Lucian must be regarded as extraordinary if not unique. From Lucian's text we learn that the rigging did not differ in principle from the ordinary rig but was simply enlarged. As a result, dimensions and weight of spars were overgrown and very unhandy. The single square-sail was difficult to handle, and the same is true of the entire rigging which had to be worked by human power. Nautical tradition was too conservative to allow the sail-area to be split into a number of more handy sails.

The carriers of late antiquity were commonly under-rigged[11]. These broad and heavy hulls were capable of carrying a great deal more sail in light weather, but in fact set only the square mainsail, the *artemon* and the twin triangular sails to the topping-lifts ('raffees' in modern terminology) called *sipara* (Gr. *sipharos* or *paraseia*). Nautical tradition, which errs on the side of cautious navigation, hampered any development towards light and swift cargo-ships. More effieient rigs, enabling windward work, were not accordingly developed during late antiquity. During the Dark Ages progress has been noted within the Germanic areas of northern Europe, while the Mediterranean remained an area of nautical stagnation.

In very light airs ships were carried by currents[12], while in a stiffening breeze the finer points of making to windward were impossible; and in rough conditions skippers soon had to brail up their sails and hoist the vulnerable steering oars letting the ship drift to leeward under bare masts. If possible the high stern was turned to windward to take the punishment of the seas. Such a rig represented a low grade of efficiency and caused seafaring to be a risky business with frequent total losses.

Fine weather and moderate breezes were essential conditions for the sailing cargo-ship which had to rely on good luck to avoid the perils of the sea. Thus not only the crews but shipping adventurers and investors felt that they depended on 'acts of God'. The cargo-carrying coaster[13] (which we know as the *navis codicaria* on the Tyrrhenian coast but the equivalent must surely have existed in Aegean and eastern ports too), related in many respects to the full-sized carrier, was apparently unmanageable when carrying the square rig, and had thus to develop a handier rig which permitted easier manoeuvring.

From the point of view of rigging the most valuable representations in this period are: the tombstone of Naevoleia Tyche (Rom.1), the Portus relief (Roman 8), and the floor mosaics from Sousse, Themetra etc. The interpretation of these pictures is doubtful since the artist's preoccupation seems to come between us and the actual ships. He frequently tries to simplify and elucidate, rather than faithfully reproduce, complex material which he has not fully understood. There result many apparent errors or logical impossibilities.

The Portus relief (Rom.10), dated to about 200 AD, gives a lot of information (if the reconstruction is to be trusted) about shrouds and stays, running rigging and the handling of sails. The twin backstays are here replaced by a sturdy set of shrouds, set up by lanyards and fixed to eyebolts at deck level. These shrouds give support sideways as well as backwards, being situated well abaft the mast. Wooden battens are seized horizontally to the shrouds above the dead-eyes to act as fairleads for the running rigging, an arrangement which is found in rigs from the 16th and 17th centuries. Lanyards are not fitted to the shrouds, but rope-ladders on the aft side of the mast give access to the yard. Working aloft was not necessary in rigs of early antiquity[14] but the handling of the triangular topsails[15] and the belaying of the heavy brailed mainsail required hands aloft. A forestay of extraordinary dimensions was led to the area round the *artemon*-spar where it ended in a huge dead-eye with two holes for lanyards. Possibly these were taken round the *artemon*-spar and through the main deck. The details of this arrangement including the stays of the *artemon*-spar were omitted by the artist.

The main yard is hewn from a solid timber with imposing sections. It is suspended from a complicated pattern of topping-lifts and is hoisted by twin halyards taken through sheaves indicated by bulges in the mast[16]. The function of the halyards and topping-lifts in relation to each other is not clear, since the triangles made up of the mast, the yard and the topping-lifts are covered by the sails called *sipara*. The combination of the mainsail and the *sipara* as well shown in the sarcophagus relief (Rom.22), where the yard is fully covered by canvas. We have to rely on guesswork as to how the *siparum* was set. There are actually two separate sails so that the heavy forestay can pass through the gap between them. The handling of these sails required, as has been said, crew going aloft at least to the level of the main yard. The lesser ship in the Portus relief, on the right hand side, shows two hands at work above the main yard, swarming the topping-lifts. The yard is fitted with foot-ropes, since one hand is shown working close to the yard-arm with his feet in the bight of a foot-rope.

The sail, built up horizontally with double parallel seams, is seized to the yard and thus hangs below the spar. Leeches are coarse and like the whole sail of rough fabric. Sheets are attached to the leeches directly by splicing, not to a cringle or an eye sewn into the leech. The clewlines (brailing ropes) are on the fore-side (lee-side) of the sail rove through eyelets or cringles sewn into the canvas. A great number of leaden rings, like rings for curtain rods, have been recovered from underwater wreck-sites[17], dated to the late Hellenistic period or the Empire. It seems likely that these leaden rings, mentioned by Herodotus (II 36), belong to sails. Unfortunately the artist omitted to show how the clewlines passed the yard and were taken down to deck-level. The ropes were probably led through eyes or ferrules seized to the yard or the leech since actual blocks would have been too heavy. Among the leaden rings mentioned we find large ferrules with two openings for seizings[18] strong enough to take the weight of the sail. The archaeological material now at our disposal does not allow a conclusion to be reached.

The graffito from Pompeii depicting the ‘Europa’ brings us closer to these questions. Here the mainsail is seen from abaft with the clewlines from the yard meeting at a point in front of the helmsman. This arrangement is in fact the single practical solution to the problem of belaying a great number of running ropes which nevertheless serve a single purpose. These clewlines were slackened, with the sail sheeted and braced, to allow for variations in the angle of bracing. When hauled tight (thus brailing up the sail) this pattern of lines locked the yard. The operation of bracing the sail so that it set fore and aft (possibly required by harbour regulations) involved a difficult re-trimming of the clewlines. The *artemon* sail is shown too small to be of significance. The rigging of the ‘Europa’ is otherwise of no interest.

The African Floor-mosaics

At this point the floor-mosaics – or fragments of them – from Sousse, Themetra etc., published and commented on by L. Foucher become relevant to the argument. T 7 shows a sailing cargo-ship with a forefoot and an exaggerated sheerline. It carries a fairly large *artemon* spar and sail. The sail is sheeted to a beam wind so that the yard is trimmed to a vertical position (like the sprit-sail yards in the 17th and 18th centuries[19]). This odd-looking position is repeated in the mosaic S1. In T & we observe the *artemon*-spar to be well stayed forward and aft. In T 2 we find three stays leading aft and two forwards. In T 1 the number of stays is equal. In the representations just mentioned the single forestay of the main-mast is omitted by the artist, quite unrealistically.

The mosaic T 8 is the most important for our knowledge of the rigging of the late cargo-ship. It shows a fairly large-sized carrier with a moderate sheer-line and many important details. The main rigging is hidden behind an extra-ordinarily lofty mainsail, shown foreshortened. The shrouds are placed in a wrong position by the artist, but the *artemon*-rigging is reported with the utmost care. The stays holding this long, inclined, spar are secured close to the main shrouds, while braces and sheets for the *artemon*-sail are carried far aft. Since counter-braces (leading forward from yard-arms) were unknown in antiquity the handling of the *artemon* in a beam wind with the help of sheets alone must have been a tricky operation.

T 8 also exhibits a detail appearing nowhere else. A set of bowlines from the standing leeches of the mainsail are shown carried to the top of the *artemon*-mast. In fact both bowlines are attached to the weather-side leech, possibly by a mistake of the artist. If this attachment is correct, bowlines must have been transferred where they were needed.

Foucher[20] stresses the unique features of this fine floor-mosaic, which must certainly be regarded as quite the most important representation of a cargo-carrier in late antiquity. The hull is well proportioned and rests correctly on the surface of the sea, while the standard rigging is reported with all the care of a seafaring man. The *artemon*-rigging is developed into an independent working fore-rig. Minor irregularities apart, the sails and running rigging are shown with a care approaching the standard of the early 16th century. This mosaic may by itself represent the seagoing cargo-carrier of late antiquity in its final and ultimate Mediterranean shape, since comparative material, e.g. coins, from the 4th century AD is lacking.

Fore- and Aft-rigged ships in the Late Empire

The need for more handy and weatherly rigs in coasters and river-craft has already been stressed. Typical of such categories is the *navis codicaria.* Since these fairly small and clumsy vessels would be in perpetual difficulties close to a harbourless lee shore if equipped with the ordinary square sail, a more workable rig was a necessity.

Of the three sailing vessels depicted on the Ny Carlsberg sarcophagus from Ostia (Rom.12) two represent the ordinary sea-going rig with the *artemon,* while one is equipped with the sprit-rig on a mast stepped far in the bow, close to the upright bollards. With a limited crew this handy rig (which was independently reborn within the North Sea area in late medieval times) must have given increased manoeuvrability to coasting vessels. A mural from a tomb in the Isola Sacra now in the Vatican Museum shows a vessel in which the mast is stepped far in the bow (Roman 14)[21]. A sailing coaster appears in the relief built into the wall of Salerno Cathedral (Rom.13). It is shown with the mast collapsed forward; unfortunately the artist has omitted spars as well as sails and gear. The same is true of the floor-mosaic from Ostia (Rom. 11 c) in black and white technique, which depicts the transshipment of *amphorae* into a coaster; here however the mast has been left in an upright position. A tombstone in the Archaeological Museum in Istanbul[22] shows a smallish cargo-ship running before the wind under twin sprit-sails hoisted to a mast stepped out in the bow. No details are forthcoming from this simple picture but this unique stele is evidence that when running before the wind a ship could hoist twin spritsails in place of the ordinary square-sail.

In the Ny Carlsberg sarcophagus the spritsail is shown as plainly as anyone could wish in contrast to the standard rigs of two obviously sea-going ships. The sail is made up of small, almost square, canvases. The upper leech to the outer corner of which the sprit is attached shows a coarse rope, while the standing and bottom leeches apparently lack a reinforcement of rope, yet from practical considerations they must have had it. Behind the sail which curves outwards in the relief the artist does in fact show the sprit. In the 17th and 18th centuries the sprit was handled in the fashion shown here with ropes (guys) controlling the swing of the sprit in as much as the sheet alone did not affect the upper area of the sail. Such an arrangement can be observed in Dutch sprit-rigged coastal craft. Unfortunately the artist did not pay sufficient attention to the fitting of the sail to the sprit, which was probably effected by laying a cringle of the upper leech-rope to cover the top of the spar. The detail is of interest because it will explain how the spar was shifted from starboard to port when coming about in tacking, the crucial operation common to the sprit-, lateen- and lug-rigs. The sprit-rig is found in a single version and with one sail only. Apparently the combination of the *artemon*-sail of small dimensions with the weatherly spritsail was not considered feasible, possibly because a square-sail, for technical reasons could not be trimmed to a corresponding angle. Triangular staysails never appear in antiquity.

There is reason to think that the sprit-rig existed in coastal and river traffic only, as was the case in Nordic waters from the 16th century onwards. In offshore work over long distances the properly stayed square-rig was predominant. Navigation in the open Mediterranean was founded on seasonal thermic winds, enabling the ships to run before them. For such purposes the square-rig is the best devised. In the ancient sprit-rig, the details of which are not very clear, no backstays are visible. In the sprit-rig on the Ny-Carlsberg sarcophagus only a heavy forestay is to be seen. Reliable staying for running before the wind would have required backstays fitted with quickly operated tackles to be set and let go, but this was probably too advanced an idea for that time. The sprit-rig was technically fragile and probably regarded as a temporary arrangement by professional sailors and suitable only for the fleet of auxiliary craft plying in sheltered harbour areas, river estuaries and canals.

The development of the ancient sprit-rig is obscure[23]. It is apparently associated with the *navis codicaria* type, but there is no reason to regard it as a specifically Roman invention. It is more likely to have been an eastern or Aegean solution of the 4th or 3rd centuries BC arising from the need for handier transport between the islands. The concentration of such representations to the coasts of Campania and Latium is, of course, a consequence of government policy which directed shipping towards the main terminals serving the *annona* organisation. The stelē in Istanbul, showing twin sprit-sails, speaks for the existence of lighters and barges in the Bosphorus also, at least when the flow of Egyptian grain was diverted towards Byzantium and Constantinople.

Until the second World War the lateen sail, together with the rig peculiar to it, was considered an Arabic invention which spread towards the Byzantine area and thus into the west. This opinion was gradually modified until eventually the rig was regarded as an invention of the reign of Justinian in middle of the 6th century. It is possible that this rig was in fact originally Indian and that it spread from India towards the Persian Gulf in one direction and Indonesia in the other. In some interesting studies Lionel Casson[24] puts forward a theory that the lateen sail, in two variants, was already known in the 2nd century AD and in regular use during the 3rd century in the northern Aegean. The lateen sail belongs to the period dealt with in this book, the Empire, but since it is not relevant to seagoing cargo-ships, further consideration of it may be omitted.

NOTES ON CHAPTER VI

1. Morrison and Williams *op.cit.* give a single representation from the Proto-Geometric period (Pl. 1 d): a bell-shaped crater in the Heraclion museum, Crete.
2. Phoenician ships depicted by Egyptian artists in a tomb at Drah Aboul Neggah l'Illustration, *Histoire de la Marine* p.30, 31, 32, carry a simple rig consisting of a short mast, an upper yard lacking topping-lifts, a lower yard suspended by numerous topping-lifts and weighed down by strapped weights or stones. The mural is cleverly reconstructed by the French naval painter A. Sebille.
3. The Odyssey Books VII, XIII and XV.
4. Halldin *op.cit.* Fig. 61 (Pylos), Fig. 62 (Proto-Geometric); Casson *The Ancient Mariners* pl.3 c (Asine).
5. Morrison and Williams *op.cit.* Pl.13.
6. S.Pagliero *Origine e diffusione delle navi etrusco-italiche.* He supposes the existence of 'national' Italo-Etruscan ship-categories differing from ships of Greek or Semitic origin. He refers in particular to the Aristonothos crater (Museo Capitolino), a pyxis from Veii (Louvre Pagliero Tav. Li Fig. 17) and a vase of Vulci type (Pagliero Tav. Li.) These show ships shaped like birds and fishes etc., which a serious scholar should not take seriously.
7. Torr, in Daremberg-Saglio: 'Navis', expresses the following opinion: 'Les grands peuples de l'antiquité........ forment comme un même race en ce qui concerne les choses de la mer. Sans doute il y a eu, là aussi, des divergences de détail, mais en tous les points importants un navire Etrusque ou un navire romain d'une période quelconque devait étre à peu près semblable à une bateau phenicien ou à un bateau grec de la même périod!
8. Persson, *op.cit.* cites the text by Athenaeus.
9. L'Illustration *Histoire de la Marine* p.34. Ownership and location of the model unknown.
10. Torr *op.cit.* p.25, while criticising exaggerations by 19th century scholars, suggests 250 tons as the mean capacity of the Roman cargo-carrier. Jules Sottas in 'A Model of the Portus Ship' M.M. 21 (1935) suggests 10,000 modii = about 86 tons, but misinterprets the edict issued by Claudius (Suetonius *Claudius* 18-9) in which 10,000 modii was set as a threshold for Imperial subsidies to owners. Casson in 'The Isis and her voyage' calculates the extreme capacity of the wheat-carriers as 1200-1300 tons regarding Lucian's figures (*Navigium* 5) as reliable. Average carrying capacity in late antiquity was probably below the 250 tons given by Torr, but the wheat-carriers operated by subsidised Alexandrian owners were considerably bigger.
11. The average speed of the sailing carrier may be deduced from literary sources taking into account the prevailing seasonal winds. Casson sums the distances covered by the Isis in Lucian's account against foul head winds and reaches an average speed of 2 knots. Running before the wind the ship reached a speed of five knots or thereabouts. These insignificant speeds were a consequence of the general under-rigging and-canvassing of cargo-ships in antiquity.
12. The big carrier was possibly moved by sweeps or towed in sheltered conditions, but this would have been impossible in a light seaway or against a light current.
13. Only the Roman coaster, the *navis codicaria* is both mentioned in contemporary literature and represented in works of art. B. Nogara was the first scholar to combine the evidence of literary and archaeological sources. See bibliography.
14. From various representations we observe sails brailed up but left hanging. From the Hellenistic period onwards hands are shown going aloft using a rope ladder. Rom.1 shows men in the rigging handling the sail and climbing to the yard without foot-ropes. Rom.10 shows men standing in footropes in 17th-18th century fashion. The footrope was probably re-invented in the 17th century. For the principles of foot-ropes ('horses' in Scandinavian nautical language) see Thomas Rajalin in bibliography.
15. These sails were apparently introduced at about the end of the 1st century BC. Owing to the position of the heavy forestay a single canvas was impossible. The triangular topsails were set from the mast and sheeted to the yardarm. It is possible that the upper leech was seized to the uppermost topping-lift. The Portus relief appears to show the sail fitted aft of the elaborate topping-lifts. The *sipara* were apparently not stowed aloft but lowered to the deck for stowage.
16. The ship to the right in the Portus relief with her mainsail brailed up.
17. Benoit *op.cit.* Pl.XXX (Sketch in Ink): 'Organeaux at anneaux de plombe avec et sans tenon'. Fig. 94 (Photo): 'Organeaux et anneaux de cargne en plomb.
18. See note 17 Pl.XXX Fig.94.
19. Svensson, Sam. 'Från Rålamb till Rajalin', Sjöhistorisk Årsbok 1948. Fig. 9 and 10.
20. Foucher 'Navires et Barques etc.,' p.15.
21. The mast stepped far in the bow was the outcome of towage from land (by donkeys, oxen or crew). The towrope was belayed halfway up the mast to clear shrubs, reeds etc., between the ship and the towpath. The forward position was best for towing.

22. Casson The Ancient Mariners' pl. 15 d.
23. Casson 'The Sprit-Rig in the Ancient World' M.M. 46 4 (1960). A relief from Thasos dated to the 3rd century BC shows a fully developed sprit-sail.
24. Casson 'Studies in Ancient Sails and Riggings' American Studies in Papyrology Vol.1, Essays in Honor of C. Bradford Welles.

CHAPTER VII

Manoeuvring, Handling and Beaching of the Cargo-carrier

'Manoeuvring' is here understood as an operation carried out by sail and oar or relying on oars alone, as for example when luffing and coming about. 'Handling' on the other hand means warping or towing in places where lack of room makes manoevring under sail or oars impossible. 'Beaching' is here understood as hauling up on dry land using direct manpower and mechanical means, as well as the use of a sandy beach for careening. Since tides are insignificant in the Mediterranean advantage could not be taken of tidal action for easy beaching. Navigation proper under sail is not considered in this context.

Manoeuvring

The attempt to answer the question how the sailing ship was manoeuvred is met with an almost total lack of information, especially as far as early antiquity is concerned. On the other hand both literary references and archaeological remains supply information about the beaching of oared warships and their housing in sheds. Representations of ships under sail seldom give any indication of how they were manoeuvred. In fact only the carved sarcophagus from Ostia in the Copenhagen Glyptotek (Roman 12), as analysed by Casson[1], supplies us with a reliable and logical representation of ships moving under sail. As far as the handling of sails alone is concerned information may be derived from the relief in the House of Naevoleia Tyche (Roman 1), as well as from the Portus relief (Roman 10), where the ship on the right hand side, carrying rigging, which unfortunately is only partly preserved, demonstrates important aspects of the working of sails. In [Aristotle's] *Mechanica*[2], as we have noticed in a previous chapter, relevant texts explain the dynamics of sail as understood in antiquity. In the narrative of his sea-voyage to Rome Paul (*Acts* 27 12-40– provides useful information on general conditions and winds, and in particular on the behaviour of a large sailing ship at the mercy of a Mediterranean storm when caught at sea too late in the season. In the *Navigium*[3] Lucian reports the route of the great 'Isis' in her voyage from Alexandria to Piraeus. We are thus able to gather important facts from apparently trivial references, but these concern sailing capacity only, not handling or manoeuvrability.

From various sources, mainly by the analysis of works of art, we may reach the following conclusions, which are nevertheless subject to the over-riding assumption that the general principles affecting seafaring remain unchanged from early antiquity to the present day. We believe this principle to be true. Our starting point is the light, oared craft of Geometric and early Archaic Greece as described in the Homeric poems, fitted with a mast and rigging which could be taken down. By modern rating this would be a large undecked boat and would be housed in a shed. We meet this ship/boat in the seventh and thirteenth book of the Odyssey[4], where the nautical practice of the Phaeacians is described. There is an important passage in the second book where in the account of Telemachus's departure to Pylos the raising of the mast and sail is described in detail. The ship is rowed away from the beach until Telemachus's protectress Athena grants a fair breeze in the right quarter. The mast is then raised and stepped; shrouds and stays cut from hides are set and made taut. In the fifteenth book we learn how Telemachos brings his ship into port by oar[5] after having lowered the sail and unstepped the mast. The use of sails was only possible when running before the wind. In a headwind ships were propelled by oars provided that the wind and seaway allowed any headway to be made. The fairly light Homeric vessel was turned and manoeuvred by oars and steered by a single steering oar. Since sailing was a secondary function only we cannot speak about manoeuvring in the strict sense under sail.

In the Attic black-figured kylix (Archaic 3) we find in two slightly different representations the sail-propelled carrier of the 6th and 5th centuries, developed for short trading and for inter-island traffic but growing into a sea going area. The same type of ship is shown in one case with her sail set full and pulling, and in the other with it brailed up. In both cases the ship is fitted with twin steering-oars, lashed but turnable. No rowlocks of any kind are visible either in the freeboards or in the bulwarks raised above the maindeck. The ship appears to have relied on wind-power only. With its very modest sail-area in relation to beam and displacement this little carrier would have been slow-moving in all conditions but especially in light airs when she would have soon lost steering-way and would have become unmanageable. We have previously assumed that ships carrying such a rig would have been able to keep on course in moderate favourable winds. Manoeuvring in light airs, in crowded places or coming about on a tack, such a ship would have required a sweep or an oar temporarily slung to a stanchion in the bulwark. The crew of coasters of this small size is likely to have been reduced to a minimum and to have undertaken the following tasks: the master would have sat at the steering oars or have handled a sweep fitted aft, while two deckhands would have handled an oar a piece amidships. These ships must have been propelled by oars from their moorings to open water or towed by this own or by hired boats where there were available. A regular manoeuvre would have been the turning of the bow by the use of sweeps in coming about, as this would have been impossible under sail alone, since the turning effect of the steering oars would have been negligible (as compared with a rudder).

From the early classical period the sailing cargo-carrier is well represented in the Etruscan-or possibly Greek-wall-paintings of the Tomba della Nave at Tarquinium (Classical 1). The controversial rigging, on which comment has already been made in a previous chapter, is the earliest example of a composite rig, soon to be adopted by trading ships of increasing size. The ship depicted is of considerable dimensions and thus of great displacement, yet the rudder action is limited. The *artemon* mast, not upright but tilted forward from the perpendicular, adds to manoeuvrability, since the sail would push the bow down-wind and thus ease steering when the ship was running before the wind.

The *artemon* rig is to be understood as the outcome of experience in oared ships, which employed a small square-sail hoisted to a spar stepped obliquely in the bow. This sail enabled oared warships to run before the wind when the situation called for a fast retreat[6] needing no effort from the oarsmen. Such an auxiliary arrangement was adopted in sailing ships as a first step towards a composite rig aiming at some degree of manoeuvrability under sail alone.

We may recall the comments of [Aristotle] in the *Mechanica* (actually put in the form of questions and answers) on the difficulties of keeping a straight course under sail in heavy weather: 'Why when they wish to sail with a favourable wind and the wind is not in fact favourable' (i.e. when it is on the quarter or abeam) 'do they brail up the part of the sail near the helmsman' (i.e. the leeward part of a square sail braced round fore-and-aft), but let out the brails of the part towards the bow' (i.e. the windward part)' making a foot (i.e. virtually making a square-sail triangular in shape with a 'foot' at the bottom corner, c.f. Vergil *Aeneid* 828-32 and *GOS* p.312-3)? 'It is because the steering-oars' (which counteract the effect of the leeward part of the sail and thus prevent luffing) 'cannot prevail over the wind when it is powerful' (as it would be if it struck the unbrailed leeward part of the sail)' but can prevail when the wind is weak' (as it is when it strikes the brailed leeward part); 'and accordingly they reduce' (i.e. brail up) 'the leeward part of the sail. So then the wind drives the ship forward and the steering-oar makes the wind favourable, acting counter to it and having the effect of a lever with the sea as a fulcrum'.[7] This argument concerns a ship with a single square sail. The brailing up of the leeward areas of the sail reduces the tendency to bring the hull bow to wind, the forward area counteracting such forces. Such measures show that the action of the steering oars in such conditions was almost zero, and the pitching of the hull is likely to have been heavy enough to disturb the steering oars and cause these to be brought up to a horizontal position. In bad weather with a rising seaway the sailing ship would have lost steerage and is unlikely to have been able to run before it under a reduced mainsail alone. The presence of an *artemon* sail would have made the sail manoeuvres described by [Aristotle] unnecessary. Running before a heavy seaway would have put the fragile steering-oars to a severe test and is likely to have caused them to be raised, and the ship would in actual fact have been abandoned to the mercy of the winds as sea, as Paul narrates in his description of his dramatic voyage from Syria to Puteoli[8].

On the Conteneau sarcophagus, dated to the 1st century BC, we already find the cargo carrier of the early Empire developed almost to its final shape. The first centuries AD witnessed merely a further increase in dimensions, in displacement and in the need for manpower. Thus there is no reason to regard this ship-representation as making a stage in development as far as handling and manoeuvrability are concerned. Yet there is reason to study the sailing capacity of this very category of ships may be divided into seagoing carriers of growing dimensions and into coasters and sail-propelled barges. There are many affinities between these groups of ships, but there are differences too, in respect of their ability to move, turn and manoeuvre. In late antiquity we find the spritsail as well as the lateen sail, both of which make possible considerable improvements in actual sailing and manoeuvring. These innovations however, as belonging to the Byzantine age, are not dealt with in the present study.

We find the sail-propelled lighter or coaster, the *navis codicaria,* as well as the seagoing carrier, well represented in works of art deriving from the estuary of the river Tiber and the adjoining artificial imperial ports. Only the sarcophagus from Ostia (Roman 12) is relevant to manoeuvring under sail and the handling of canvas. In this elongated relief we see three ships apparently in a common situation, the area in which they are sailing being limited by a lighthouse at one end and a construction which looks like the end of a jetty or mole at the other. To the left a seagoing carrier of the *corbita* type is leaving port, running before the wind which is blowing towards the spectator. This ship overhauls a *navis codicaria* (centre) under a spritsail which turns towards the wind to avoid running into a second *corbita,* which is entering port close hauled but has to back her yards to avoid a collision. All this confusion is apparently being caused by a young man (centre), in the water but apparently unable to swim, whose little craft is seen drifting in the area which may be understood as the estuary of a regular port, most probably the *portus* constructed by Claudius on the most advanced pattern. On the ship to the left side the drowning man is noticed, and two crew members prepare to rescue him. The ship remains on her course but the mainsail and the *artemon* are partially brailed up. On the *navis codicaria* (centre) which is turning into the wind, one deck hand is adjusting the sheets of the spritsail, while a man in the bow keeps his eye on the approaching *corbita* (which is coming dangerously close) while apparently belaying some ends of the running rigging. On the right-hand *corbita,* with *artemon* and mainsail backed but heading towards the entrance of the port, the helmsman watches the situation and keeps his crew on stand-by for any manoeuvre which may be required. The ship is making no headway and does not respond to her steering oars. As the wind works on the *artemon* the ship's bow must soon veer towards the spectator. This relief is of extraordinary importance since the artist has given us what is apparently a 'snapshot' of a dangerous situation and has thus presented a series of unusually significant details of rigs, sails and running gear in situations which are individual and logically understandable.

The *navis codicaria* carrying a single spritsail was beyond doubt a livelier vessel compared with the sea-going carrier of the *corbita* class. With the spritsail hauled close this vessel may have maintained her speed when making to windward in manoeuvring, while being unable to work to windward by methodical tacking. The diagonally arranged sprit is actually shown behind the sail (where it should properly be), as the spar has to be shifted from side to side when the turn was made to the opposite tack. This simple rig enables the *navis codicaria* to navigate rivers and canals where she would have been towed by her crew or by hired animals or by slaves working along a towpath.

The seagoing carrier is here shown entering and leaving port in a crowded area, under sail but with her squaresails brailed up and the working area reduced to about a half. The *artemon* sails, which are shown of a very modest size, are not brailed up but show a pattern of pleats between the parallel vertical buntlines, curtain fashion. The importance of this sail is shown by the mosaics from Sousse, Themetra etc., (Roman 20). The backing of the mainsail, which would have caused the vessel to stop, is a basic manoeuvre. This manoeuvre, while the *artemon* was propelling the ship forward, produced a situation in which the two forces were counteracting each other and the heavy carrier would have been more manoeuvrable. We must remember that at low speeds the effect of the steering-oars was weak by comparison with the hinged rudder of medieval times[10]. Thus forces applied at the extremity of the bow, and there exerting the maximum leverage, would have increased the manoeuvrability of the vessel, at any rate at low speeds.

The manoeuvre which the Ostia relief depicts shows that the *artemon* sail would have made the bow to fall off the wind if the ship was brought up into the wind by the force of sails or steering-oars. Theoretically the brailing up of the *artemon* could have made luffing easier, but we know nothing of such operations.

In the mosaics from Sousse, Themetra etc., we find important indications of the method by which the sailing carrier was handled:

T 2 : a cargo ship in which the mainmast has been lowered towards the stern shows the *artemon* sail carefully furled to the yard (naval fashion in 19th century style with the sheets neatly trimmed). The area of this latter sail alone is large enough to move the ship. The yard rests in four topping-lifts, but the artist has omitted the braces. From a late mosaic from Dougga (Tunis) now in the Bardo museum we know of the existence of sheets as well as of brances serving the *artemon* sail. While artistically of a good class this ship representation (T 2) is naive and erroneous.

S 1 : an oared ship with a composite rig shows the *artemon* mast longer than the mainmast, also the *artemon* sail is apparently carried too high. There is reason to consider this ship as a mere artist's phantasy. Of extreme interest is the fact that the *artemon* sail is braced round for a beam wind, the yard remaining at an angle of 90° to the raked mast as governed by the topping lifts and turned as a result from a horizontal to an almost vertical position. In the same way in 17th-and 18th-century rigs square sails set below the bow-sprit, with the appearance of triangular jibs, were in the late 18th century trimmed to a vertical position, a practice which replaced the earlier method of reefing the rectangular sails diagonally and bracing the yards sharply[11].

T 7 : this ship confirms further the method described above. It exhibits a still bigger *artemon* sail (relatively to the mainsail) sheeted and braced in a similar way. The sail is sheeted home and bracked back almost flat with the yard in a vertical position, as the position of the *artemon* sheets further show. On the lee side the sheet is brought far to the stern while the weather sheet is belayed in the bow. Furthermore the shadows on the sail, cleverly observed by the artist, stress the fact that the canvas is stretched flat.

T 8 : This is the most important of these ship-representations, and provides definite evidence for the *artemon*-sail (here still bigger in relation to the main-sail) being used close-hauled in light winds, possibly in beam winds some point on the bow. We further learn from this mosaic that the mainyard also was braced to an angle of about 45° to the centre-line of the hull, which would enable the ship to sail in light winds, The *artemon* yard is here fitted with braces[12], a feature which gives reason to assume that these were omitted by the artists in the mosaics described above, since this yard cannot have been managed or have remained secured by the sheets alone.

In earlier contexts we have stressed the existence of bowlines for the mainsail carried to the *artemon* mast, their purpose being to stiffen and secure the weather-leach when the ship was running in a beam wind. For windward work bowlines are essential. There is thus reason to believe that the rig of the seagoing carrier was developed to such an extent in the second and third century AD that there was provision for windward work, although on a very modest scale[13], since hull-forms did not favour such ambitious practice.

What may we conclude from these mosaics as to handling and manoeuvring? The ships depicted are all shown keeping a steady course with sheets and braces belayed. Thus we must advance carefully by indirect methods. The increased area of the *artemon* sail may indicate that the composite rig was found easy and practical and was thus further developed. The growth in importance of the secondary sail was the outcome of the greater handiness of the ship thereby. The *artemon* sail was a 'driver', as well as an auxiliary sail making possible certain manoeuvres. Like the mainsail it was no doubt brailed up from deck-level. With the development of the *artemon* rig Aristotle's picture of a mainsail with its after (leeward) part brailed up relieving pressure on the steering oars when the ship was running with a wind on the quarter, is no longer relevant. It was, as we saw, concerned only with a ship setting a single main sail. When the mainsail ceased to be elongated in the manner of the archaic and classical periods and became almost square, the practice described by Aristotle would have lost its significance and remained as only a literary curiosity.

A ship of this type could possibly have been brought about (i.e. turned by bringing the bows up into the wind) by luffing through action of the steering oars. But this manoeuvre would hardly have succeeded unless the *artemon* sail was brailed up at the critical moment and was employed again in bringing the bow to leeward on the fresh tack. Such a function is hypothetical since we are completely lacking in relevant information, but there is reason to believe that the *artemon* rigging had such a purpose and would have acted like a modern jib exerting a considerable force. Whether or not the *artemon* rig had such a function in heading up-wind, it was certainly instrumental in causing the bow to fall away before the wind, an essential function in a turn to the other tack down-wind. There is no literary evidence for these assumptions, but fortunately we may rely on the Ostia sarcophagus (Roman 12) as we have interpreted it above in which the accomplished artist has depicted joint manoeuvres of this kind.

Handling in Port

In Chapter V we have discussed the general rise in displacement and the corresponding need for the power of human muscle. We concluded that the growing sizes of ships set a limit to handling by direct muscle-power in warping and hauling. From the Hellenistic period the handling of anchors, warps and springs required windlasses, capstans and similar machines. The subject of the present section is the handling of ships in crowded area where sail is out of the question and the use of oars is inconvenient through the lack of room, shortage of deckhands, etc.. Coasters and barges are here excluded as these categories were developed to carry sails or to manoeuvre with the help of a few oars possibly both in combination.

The cargo carrier of *corbita* size was a bulky and heavy vessel, under-rigged and under-canvassed by 18th and 19th century standards. Yet it appears from the Ostia-sarcophagus (Roman 12) that such ships entered or left port under sail alone, at any rate in favourable winds and a moderate seaway.

Certainly ships anchored in roads in the lee of breakwaters and with ample space around them. The ships of the biggest categories known anchored off break-waters. We may find the successive stages of ship- and cargo-handling by studying the development of technical port facilities in the Tiber estuary, serving the imperial capital with its steadily growing population[14].

(a) Before the construction of the artificial port (Portus) connected by a canal to the river, ships entered the difficult mouth of the Tiber (with Ostia built on the left bank).

(b) When Claudius' breakwaters had been completed ships and cargoes were handled in the relative safety of the sheltered basin. Cargoes were here reloaded into coasters or barges which served local merchants.

(c) Absolute safety was finally achieved by the grand schemes of Trajan who built a landlocked artificial basin adjoining Claudius' harbour, which from now on served as the spacious roads for the new facilities.

From the roads ships were brought into the basin by tugs or alternatively by warping, a heavy task requiring a sturdy launch capable of handling anchors and warps. The trans-shipment of cargoes required an assortment of lighters, barges and small craft propelled by oars or towed by oared prams[15].

We are fortunate to have an almost complete picture of the various functions within a major port – the area of the 'portus uterque' – put together from a combination of epigraphy and works of art[16]. Active within the Portus-Ostia area we find five corporations or guilds recorded in the second or third centuries. The Lenuncularii Pleromarii Auxiliarii and the Lenuncularii Tabulariii Auxiliarii probably had responsibility for barging, cargo-handling and towing. The latter guild was possibly authorised to carry out the duties of the port-authorities in checking documents, cargoes etc.[17].

Towing of barges *(lenunculi)* and small-sized cargo-craft *(lintres)* and in particular of the cargo-carriers themselves called for powerful oared boats propelled by numerous oars. On a tombstone recovered from the Isola Sacra on the right bank of the Tiber and dated to the reign of Hadrian[18] we see such a tugboat with three pairs of oars and the helmsman standing at the steering-oar, which is not rotated like the rudder-oars of sea-going ships but swung from an upright pivot. The tow-rope is belayed to the stern. The handling of heavy cargo-vessels in crowded areas was entrusted to skilled professionals whose qualifications for these duties possibly had to be approved by the relevant authorities. According to Dionysius of Halicarnassus oared ships and cargo-ships as well, of considerable dimensions, were towed up-river to the wharfs and storehouses of Rome[19], normally served by the vast fleet of coasters, barges and lighters etc., in constant activity.

The Portus-relief (Roman 12) shows ships of the *corbita* class in the inner basin of the Portus area; and we may infer from this evidence that ships in general were moored with their bows to the jetty and their anchors dropped from the stern[20]. Today Mediterranean ships are mostly moored stern to the jetty. Both these methods save in the length of the wharf occupied by a single ship, with the result that the area of a closed basin is more effectively used. On the other hand the handling of cargo is hampered by the necessity of carrying commodities along planks laid over the bow or stern, discharging alongside being the speedier method. As to the handling of the *codicaria* class or its equivalent our sources do not show these vessels discharging cargo alongside wharfs or sea-going ships, but commodities are handled along planks over the bow.

In addition to towage, hauling by warps within closed areas using capstans must have occurred, and this would have required fixed mooring points at fairly short intervals. Bollards or holed stones erected on the quay must have existed in regular ports of the classical period. Holed stones are documented in reliefs as well as found *in situ* in excavated sections of imperial jetties on the left bank of the Tiber[21] which were revealed during construction work in the 1860's and 1870's.

We have already commented upon windlasses and capstans. The vertical 'standing' capstan is much more convenient for hauling and warping with river-anchors by comparison with the horizontal, barrel-shaped, windlasses, the capstan being the faster device. In describing the 'Isis' Lucian makes specific mention of deck-machines of different categories, vertical and horizontal windlasses[22]. The large number of power-saving deckmachines on this huge carrier arises from the extra-ordinary need for power in the handling of the hull and of the immense rigging which had become unhandy[23] through the mere increase in the linear dimensions and in the working sail-area.

The Beaching of Ships

The oared ship carrying an auxiliary removeable light rig, as known from the Homeric poems, was beached by her crew of able-bodied oarsmen. The Phaeacian ship which carried Odysseus back to Ithaca on Alcinous's orders (*Odyssey* 13 114-5[24]) demonstrates her speed combined with low weight and robust structure by running up on dryland to half her length.

In spite of increased dimensions and heavier build the Greek oared warship in the classical period was still beached by her crew by improvised means. The permanent shipsheds and slipways, e.g. in Piraeus[25] (Zea, Munichia) and Apollonia,[26] enabled oared warships to be easily beached for housing. There is no information about the machines which may have been fitted in the stone-built sheds.

The beaching of loaded ships may have occurred in early times when light cargo were carried in oared ships, but in general a loaded hull should not be beached since severe strains would be caused where there was structural weakness and critical joints. The *diolkos*[27], the famous marine 'railway' across the isthmus of Corinth, may have been an exception to this rule in as much as loaded hulls of modest size were transported on trucks from sea to sea. In fact we lack information about the cargoes of these ships, which may have been transported separately by mules or donkeys. This permanent paved road operated by the city of Corinth and mentioned in classical authors is known as a result of excavations at both ends where the pavement with worn tracks from wheels was unearthed. Unfortunately we do not know when this important and lucrative traffic ceased, which would have been of importance to vessels of small dimensions only.

What are the possible requirements for the task of beaching a cargo-ship roughly the equivalent of a modern coaster or sea-going fishing-boat of between forty and eighty metric tons burden? Modern parallels may provide an answer, since Italian coasters are beached locally without the use of slipways or technical facilities, and heavy pleasure boats with deep ballast keels are handled in a similar way by modern Italian boatyards. A flat-bottomed hull, even if it is of considerable weight, may be more easily beached than a smaller but narrow and deep hull like a sailing yacht. The handling of such a hull requires a rigid and robust structure, 'a cradle'.

The first requirement for the operation is an even and hard sand bottom, without shoals and bars, allowing ships to approach and to be handled and stepped on rollers launched and kept in proper position by a number of assistants. The second requirement accordingly is either a sheltered beach behind breakwaters or a dead calm. Such beaches are frequently found close to towns from early antiquity in Phoenician and Greek areas, since they were essential for the housing, maintenance and launching of fleets of light, oared ships. The necessary power must have been supplied by the crews and volunteer townspeople, possibly by horses or oxen, and at a more developed stage, by movable wooden windlasses as described by Herodotus[29]. The methods for securing such movable machines in sand or in a pebble beach may be studied, for instance, along the Adriatic shore of Italy, on the islands of Capri or Ischia (Plate XXXI), and around the southern shores of the North Sea where fishing boats are hauled up as a regular practice.

The method is not narrated in literature, nor depicted in works of art, but survives to the present day in nautical practice (Plate XXXII). Cradles were not apparently used in antiquity but pulleys were applied directly to the hull. Wooden rollers were placed under the bottom and a number of assistants was required to keep the rollers in position until they were caught by the ship. A hull with sharp lines would have tilted sideways as soon as the water ceased to support it if it was not kept upright by a number of assistants. Movement on land requires a flat 'hard' and a supply of wooden rollers which should rotate exactly parallel to each other. In modern conditions launching of coasters and fishing craft in the Mediterranean area requires a block fitted in deep water to take the cable (or wire) which pulls the hull towards the water. An anchor is usually laid for this purpose. It may be assumed that in antiquity the hulls, not resting on a cradle, were kept upright and launched by muscle power, the task being made easier by the slope of the beach. The whole operation possibly called for the mobilisation of a considerable number of hands, sailors and townspeople.

At what date was the simple wooden windlass brought into practical use? According to Athenaeus the mammoth cargo ship 'Syracosia/Alexandris', built to the order of Hiero II was launched at Syracuse by Archimedes

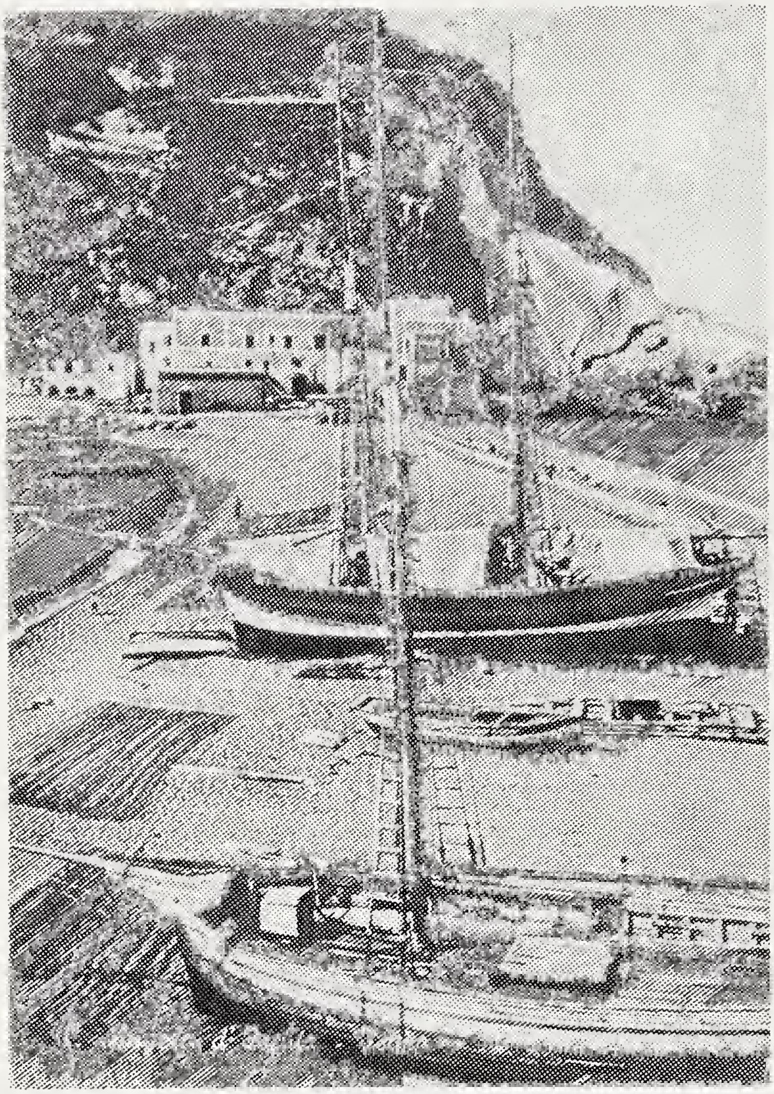

Plate XXXI
The sandy Isthmus of S. Angelo d'Ischia in the Archipelago colonized by Greeks in 8th cent. B.C. Such a beach in the tideless Mediterranean is convenient for the upkeep and repairs of medium-sized craft, hauled up by similar means. The coasters of Goleta-type of Abt. 80-120 tons, are handled by moveable capstans and an improvised "slipway", laid out in the sand. Technique was not improved since Roman times.

employing simple machines operated by a few slaves[30]. Archimedes would thus appear to be the inventor of the windlass. The event may be dated in the peaceful period of twenty three years after 241 BC when advanced agriculture and an extensive wheat export trade enabled the ruler to indulge in an extravagant programme of public architectur and fortification. It is however impossible to believe that the simple windlass could have been invented as late as the 3rd century BC, the period of Hellenistic civilisation which was in material terms the most important[31]. There is reason to believe that Archimedes' invention was a windlass with pinioned wheels requiring only a few slaves to turn the handles. The vertical wooden capstan was surely known far earlier, since certain examples of eastern monumental architecture would only have been possible with the use of certain machines. The simple wooden capstan was probably known in Greece already in the archaic period, since Herodotus speaks of machines for the beaching of ships at Memphis designed and built by Greeks in the middle of the sixth century.

The method described above is applicable to relatively heavy weights and bulky hulls. A hard and fast rule as to the upper limits of hulls which could be beached in this way with safety cannot be laid down. (From Athenaeus we know that the Syracosia/Alexandris was beached at Alexandria and allowed to go to pieces.) This is evident from the handling of Italian and Greek coasters up to a burden of about 100 metric tone. Vessels of this size are beached by the crew assisted by members of their family and neighbours, always without mechanical aids. The power of the capstan may be increased by harnessing animals to the spokes or by using pulleys with numerous sheaves; and the number of windlasses may be increased. The operation is slow, cumbersome and uneconomical of effort. The weight of the hull presses the wooden rollers into soft ground, thus requiring the laying down of battens or spars as sleepers. Difficulties increase as displacement and draught grows; for example

Plate XXXII The Basic requirements of the Greek "Polis"; the acropolis and the beach for light craft, are still to be studied along the campanian and lucanian littoral. Agropoli in Lucania, with the former castle-hill of colonial greeks turned a medieval village.

In antiquity valuable boats and light ships were stored in individual sheds; in modern times boats beached are covered by wetted carpets etc. to preserve hulls from heat. Boats are easily beached with ropetackles.

the handling of rollers becomes very difficult when draught exceeds a man's height. At this stage improvised beaching must give way to a permanent track or slipway, which could take the form of a timbered structure of sleepers or of a slanting paved 'hard'. Examples of such slipways, without cradles however, may be seen in the famous dockyards with their shipsheds which have been traced at Piracus in Zea and Munichia and again at Apollonia[32], built to fit the standard warship of the classical period, the *trieres.*

What do we know about the beaching of the heavy and increasingly large cargo carrier of late anquity without which careening and overhauls and repairs to the external underwater hull would not have been possible? The ships of antiquity were built in the open on suitable ground as close as possible to the waterfront. Shade was most probably improvised in the various ways still to be seen in the Mediterranean area. Warships were apparently built in special sheds or in the permanent shipsheds in which these precious hulls were normally housed and protected from the sun. The bulky hulls of cargo-carriers were erected close to the water and were launched in the usual way on rollers. The mammoth ship Hiero II represented a quite extraordinary problem of weight, and the difficult task of launching her was accordingly entrusted to the best-known mathematical engineer of his age.

The size of the sailing carrier, around 200-300 metric tons in the first century AD, grew in the following centuries, as we saw in a previous chapter, to a figure of around 1000 metric tons. There is reason to believe that such hulls, once launched, were too heavy for beaching and were kept afloat when idle. In the tideless Mediterranean nature unfortunately does not assist in beaching ships for a fast scrub and a new coat of paint.

Torr, in his careful survey of passages from Greek and Roman authors, never mentions slipways or such facilities for merchant ships, nor is there any archaeological evidence for such. Unfortunately the harbours and jetties of Hellenistic and Roman Alexandria were destroyed by the superimposition of Moslem building over a thousand years. Alexandria would have been the ideal place, where the basins and port-facilities of the privileged wheat carriers which regularly used this fine and famous harbour might have been looked for. Certain technical details in the hulls of these cargo-carriers confirm the conclusion that these ships were not regularly beached for overhaul. The successive coatings of pitch, linen canvas and lead sheathing which were found in the Nemi hulls [33] were at first for a time seen as the hallmark of the Roman navy, developing methods without regard to expense. Hull-coatings of canvas and lead have however been observed in the major wrecks of cargo ships which have been surveyed or excavated since the second World War [34]. The purpose of the coarse flax-canvas applied with pitch to the planking was to seal the wooden structure while the lead sheathing served to prevent the adhesion of barnacles, other marine creatures and vegetation as well as the dangerous attacks of teredos. Lead is an effective deterrent in all these cases. The successive coatings of the underwater hull of a large-sized merchantmen would have been a considerable expense which would not have been acceptable as an annual charge if the hull had been 'dry-docked' annually for regular overhaul. The purpose then of the lead-sheathing seems then to have been to keep the hull-bottom clean so as to avoid the difficulty and expense of docking. Ship-masters would without doubt have kept an anxious eye on the condition of the hull-bottom, since this would have had an effect on their anyhow very modest speed, and attempted some cleaning when in port by the use of brushes and the hiring of local divers.

In this context mention must be made of the heeling as a possible method of careening, since the technically advanced ports of late antiquity must have offered facilities for this operation, e.g. fixed points ashore, mooring bollards etc. The low, robust rigs of late-antiquity were well suited to the operation of heeling, supported as they were by ample shrouds attached to sturdy chainwales. This method, common in the fifteenth and sixteenth centuries in the Mediterranean and North Sea, is however nowhere mentioned in the literary texts. We are equally lacking in any information whatsoever on the way in which defects below the waterline, severe leakage etc., were repaired. These would have necessitated beaching, heeling or other methods of bringing the area of the defect above the surface.

NOTES TO CHAPTER VII

1. Casson, *The Ancient Mariners*, pp. 221-222.
2. Aristotle *Mechanica* 851 a 6 : this work is usually assigned to the Peripatetic School.
3. Lucian, *Navigium.*
4. Tr. E.V. Rieu.
5. Odyssey 15 495-498
6. In the late 5th century at Athens this sail was called the *akateion.* It was carried into battle, whereas the mainmast and sail were left ashore: Aristophanes *Lysistrata* 61-64. Rhodian oared ships carried a similar fore-rig named *dolon*, and Carthaginian and Roman ships used such auxiliary rigs and sails: Polybius 16 15, Diodorus 20 61. The name *artemon* appears at the earliest about 100 BC. Lucilius uses it for the tilted fore-mast of a merchant ship.
7. See note 2 above. The translation and explanatory comment is J S Morrisons.
8. *Acts* 27. The hoisting of the steering oars to avoid damage in a heavy seaway is not mentioned. There is mention of the easing of the straps securing the oars: 24, 40.
9. The forward position of the mast is the outcome of the special technique of towing from a parallel path or road by which the towline must be secured high up on the mast. Steps are therefore fitted to the mast to enable easy climbing. See Roman 13, the relief in Salerno cathedral.
10. Steering-oars are favourably commented upon by those who have had actual experience of using them in replicas of the Norwegian funeral ships. Hulls are said to react sensitively to slight turning of the oars, and steering requires no effort. The working surface of the oars is small compared to that of a rudder. at slow speeds the effect of the oars is insignificant.
11. For these problems see: Sam Svensson, 'Från Rålamb till Rajalin', *Sjöhistorisk Årsbok* 1948, pp. 105-109, Sketches 9 and 10 (an important study in 17th-18th century rigging).
12. A 4th century mosaic from Dougga exhibited in the Bardo Museum, Tunis.
13. Any course better than 8 points off the wind is understood as gaining, i.e. sailing into the wind with yards braced hard, sails close-hauled and fore-leeches stiffened by bowlines. It is however possible that sailing into the wind was not a practical reality owing to bluff hull-forms and the lack of lateral resistance.
14. Meiggs, *Portus*, pp. 149-166. Also Luigi and Filibeck, Il Porto di Roma Imperiale e l'Agro Portuense. see various articles by Boethius.
15. Casson, Harbour and River Boats of Ancient Rome, pp. 33-37, *JRS* Vol. LV (1965).
16. Meiggs, *op.cit.* : The Guilds, pp.311-332.
17. See note 15.
18. Casson, 'Harbour and River Boats etc.' Pl. I (1)
19. Dionysius of Halicarnassus III 44 3.
20. Not confirmed by ancient literary sources. Mooring stern to a jetty or to an open beach is common within the Mediterranean still today. This should be seen as an unbroken tradition going back at least 3000 years.
21. Nash, Bildlexicon zur Topographie des Antiken Roms, I, Excavated sections of imperial jetties along the Tiber in Figs. 464 and 465 (photos 1868) and Fig. 466 (photo 1953).
22. Lucian *Navigium.*
23. Casson, 'The Isis and her Voyage', pp.170-178.
24. Transl. E.V. Rieu.
25. Marstrand, *Arsenalet i Piraeus.* Graser, *Athenische Kriegshäfen.*
26. Fleaming, *Marine Archaeology*, pp. 170-78.
27. The road or track, with a distance of 6 kilometers between Lechaeum and Cenchreae – the ports of land-locked Corinth on each side of the isthmus – is rarely mentioned in literature (no reference in Pauly-Wissowa). There are some recent photographs of excavated sections in Edward Bacon, *Digging for History.*
28. Herodotus (II 154) speaks of machines for the beaching of ships left in Memphis by Carians and Ionians and which he had observed *in situ.* These Greeks had come to Egypt in the reign of Amasis (570-520 BC).
29. See previous note.
30. Persson. *'Die Hellenistische Schiffbaukunst und die Nemischiffe'*, *Opuscula Archaeologica* I p. 134.
31. Diels, *Antike Technik Sieben Vorträge*, Wissenschaft und Technik bei den Hellenen, pp. 1-6.
32. See note 28.
33. Uccelli, *Le Nave di Nemi*, Figs. 78 and 95.
34. Benoit 'Fourouilles sous-marines. L'Epave du Grand Congloue à Marseille', XIV° Suppl. à *Gallia* Figs. 83-84 Plate XXIX.

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